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MAY 1974



DATA BOOK FOR 12.5-INCH DIAMETER
SRB THERMAL MODEL WATER FLOTATION
TEST - 14.7 PSIA, SERIES P024

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12.5-INCH DIAMETER SRB THERMAL MODEL
WATER FLOTATION TEST - 14.7 PSIA, SERIES
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16. ABSTRACT

This report presents data acquired from the final series of tests conducted to determine how thermal conditions affect Space Shuttle SRB (Solid Rocket Booster) flotation. Included are acceleration, pressure, and temperature data recorded from initial water impact to final flotation position using a 12.5-inch diameter thermal model of the SRB at ambient pressure. The model was 136.9 inches long and weighed 117.3 lbm. Thirty-three valid tests were conducted from October 16 to November 2, 1973. These tests indicated the following differences from ambient temperature tests:

1. Significant negative static pressures can occur during penetration.
2. Maximum penetration is increased.
3. Final flotation is in the spar buoy mode.

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SUMMARY

This report presents data acquired from the final series of tests conducted to determine how thermal conditions affect Space Shuttle SRB (Solid Rocket Booster) flotation. Included are acceleration, pressure, and temperature data recorded from initial water impact to final flotation position using a 12.5-inch diameter thermal model of the SRB at ambient pressure. The model was 136.9 inches long and weighed 117.3 lbm. Thirty-three valid tests were conducted from October 16 to November 2, 1973. These tests indicated the following differences from ambient temperature tests:

1. Significant negative static pressures can occur during penetration.
2. Maximum penetration is increased.
3. Final flotation is in the spar buoy mode.

SECTION I. INTRODUCTION

This report presents processed acceleration, pressure, and photographic data recorded during water flotation tests using a 12.5-inch thermal model of the Space Shuttle Solid Rocket Booster (SRB). Thermal effects on the scale model during impact, penetration, slapdown and final flotation at 14.7 psia were assessed by varying the model temperature at water entry. Entry dynamic conditions were varied by using different combinations of vertical velocities and water impact angles. Test results will be used to develop analytical models for the full scale SRB and to indicate potential problem areas.

Thirty-three valid drop tests were conducted between October 16 and November 2, 1973. A description of the model, test procedure, instrumentation, and data acquisition systems is included herein.

SECTION II. MODEL DESCRIPTION

The test specimen was a model of the 142-inch diameter Space Shuttle SRB with a flared skirt and a full length nozzle. The model was a rigid body constructed of aluminum alloy 2219-T87 and contained three sections:

1. Cylindrical Section (four segments)
2. Motor Nozzle Section
3. Flared Skirt Section

Two model configurations were used:

1. Full Length Nozzle
2. Short Nozzle

Figure 2 shows the dimensions for each model configuration. The short nozzle was used to simulate the ejection of the nozzle extension. The dimensions and mass characteristics of the model were:

- Length:
 - Full Length Nozzle: 136.9 inches
 - Short Nozzle: 132.3 inches
- Body Diameter: 12.5 inches
- Skirt Diameter: 16.5 inches
- Weight:
 - Full Length Nozzle: 109.0 lbs
 - Short Nozzle: 105.8 lbs
- Pitch Mass Moment of Inertia:
 - Full Length Nozzle: 40.8 slug-ft²
 - Short Nozzle: 40.6 slug-ft²
- C.G. Location (aft of the nose plate)
 - Full Length Nozzle: 73.06 inches
 - Short Nozzle: 70.94 inches

Geometric patterns were placed on the model to aid in photographic data reduction. Twenty-four 720-watt heater strips (2.0-inch width) were placed around the cylindrical sections. Four 360-watt heaters were on the long nozzle and two on the short nozzle. The aft bulkhead had four 120-watt heaters installed. No heater strips were placed on the flared skirt. Insulation (Dow Corning Silicon Paint 93-027) was sprayed on the external surface of the model to a depth of .02 inch.

SECTION III. TEST PROCEDURE

Testing of the 12.5-inch diameter thermal model was conducted in the Over Water Launch (OWL) tank facility at Marshall Space Flight Center (MSFC). The model was suspended above the OWL tank by a quick release device at the specified initial angle. The model height above the water surface was varied to yield the specified impact velocities. After the model was in position for release, power was applied to strip heaters. When the model wall temperature reached the test temperature, the release mechanism was activated and the model was allowed to fall freely. The model impacted tail first with nominal vertical impact velocities of 5, 15, and 30 ft/sec. The nominal off-vertical pitch angles were 0°, 10°, and 20°. Average wall temperatures ranged from ambient to 450°F.

The procedure for drying out the inside of the model after each test was as follows:

1. Lift model from the water with the vent valve open to allow the model to drain.
2. Rotate the model to the horizontal position and attach a purge line to the vent valve.
3. Flow dry missile-grade air through the model while applying power to the heater strips.
4. After the model walls attain 300°F, continue purge for 5 minutes.

The test run number, nominal vertical velocity, initial impact angles and temperatures are shown in Appendix A. Figure 3 shows the coordinate system and defines the parameters used in the test program.

SECTION IV. DATA ACQUISITION AND INSTRUMENTATION

The data acquisition system consisted of acceleration, pressure, and strain gage transducers with associated signal conditioning electronics, multiplexing equipment, and analog tape recording system. An oscilloscope recorder was used to display online measurements during each test drop.

Instrumentation consisted of six accelerometers, two ullage pressure transducers, two ullage and six wall mounted thermocouples. Measurement identification numbers, transducer types, and other pertinent instrumentation details are given in Table 1. Figures 4 and 5 show the instrumentation locations.

Five cameras were placed above and two below the water surface. Two camera systems were used. A high speed (250 frames/second) camera system filmed initial impact and slapdown. This system consisted of one camera above and one below the water level that sighted the impact point along the line of descent of the model into the water. A third high speed camera sighted the impact point from a position 90 degrees away and below the water level. The second system had two low speed (24 frames/second) cameras that filmed the test from release of the model until final flotation mode. The cameras were located above the water level and 90 degrees apart in a horizontal plane.

All data acquisition systems were calibrated in accordance with approved laboratory practices and calibrations were maintained as required.

SECTION V. DATA PROCESSING AND EVALUATION

Onsite data evaluation was performed after each drop. All oscillograms were reviewed to determine the validity of each measurement and time slices were selected for time history plots. Analog data tapes from each test were sent to MSFC Computation Laboratory for reduction. A digitized time history plot for each valid data channel was made with a sufficient time slice to include model release, water impact, slapdown, and rebound conditions. An additional time history plot was made for the pressure and temperature channels which extended the time history plots to a total time of 15 to 30 seconds.

SECTION VI. DATA PRESENTATION

Model impact parameters obtained from photographic data reduction are presented in Appendix A. Parameters included are:

- o Vertical impact angle (deg)
- o Maximum penetration depth (ft)
- o Vertical angle at maximum penetration (deg)

The impact velocities were calculated from accelerometer data which indicates release time and impact time.

Acceleration, pressure, and temperature data time history plots are presented in Appendix B. Acceleration (g), pressure (psig), and temperature ($^{\circ}$ F) are presented as a function of time.

TABLE I. INSTRUMENTATION PROGRAM

MEASUREMENT NUMBER	MEASUREMENT TYPE	FREQUENCY RESPONSE (Hz)	FULL SCALE RANGE	SENSITIVE AXIS
EP001	Accelerometer	2-400	$\pm 25G$	Pitch
EY002	"	"	"	Yaw
EA003	"	"	"	Axial
EP004	"	"	"	Pitch
EY005	"	"	"	Yaw
EA006	"	"	"	Axial
D0001	Pressure	"	± 15.00 psig	Internal
D0002	"	"	"	"
C0001	Thermocouple	"	500°F	External Wall
C0002	"	"	"	Internal Wall
C0003	"	"	"	Ullage
C0004	"	"	"	Internal Wall
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C0008	"	"	"	"

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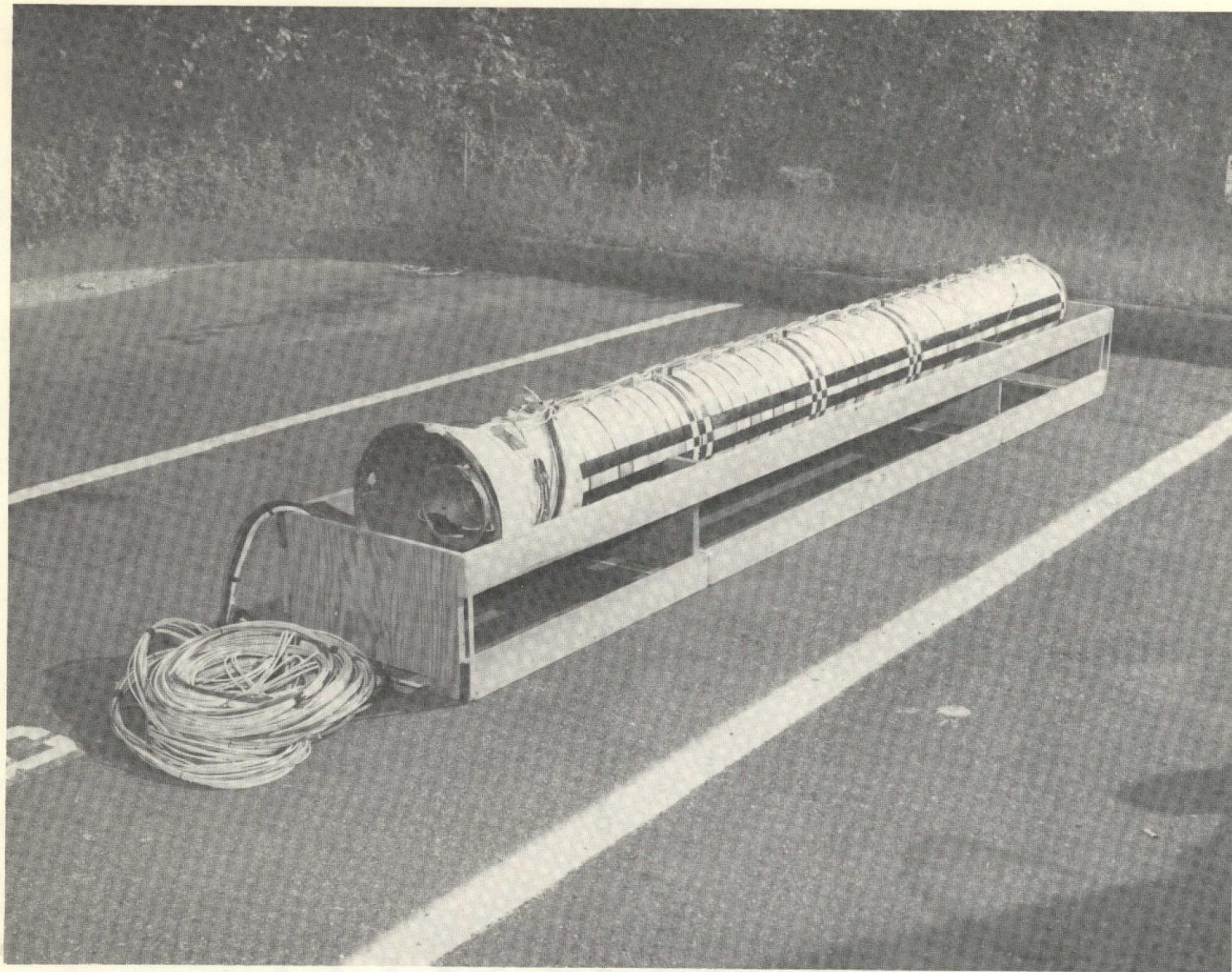


FIGURE 1. 12.5-INCH SRB THERMAL MODEL

NOTE: DIMENSIONS IN INCHES

- 11 -

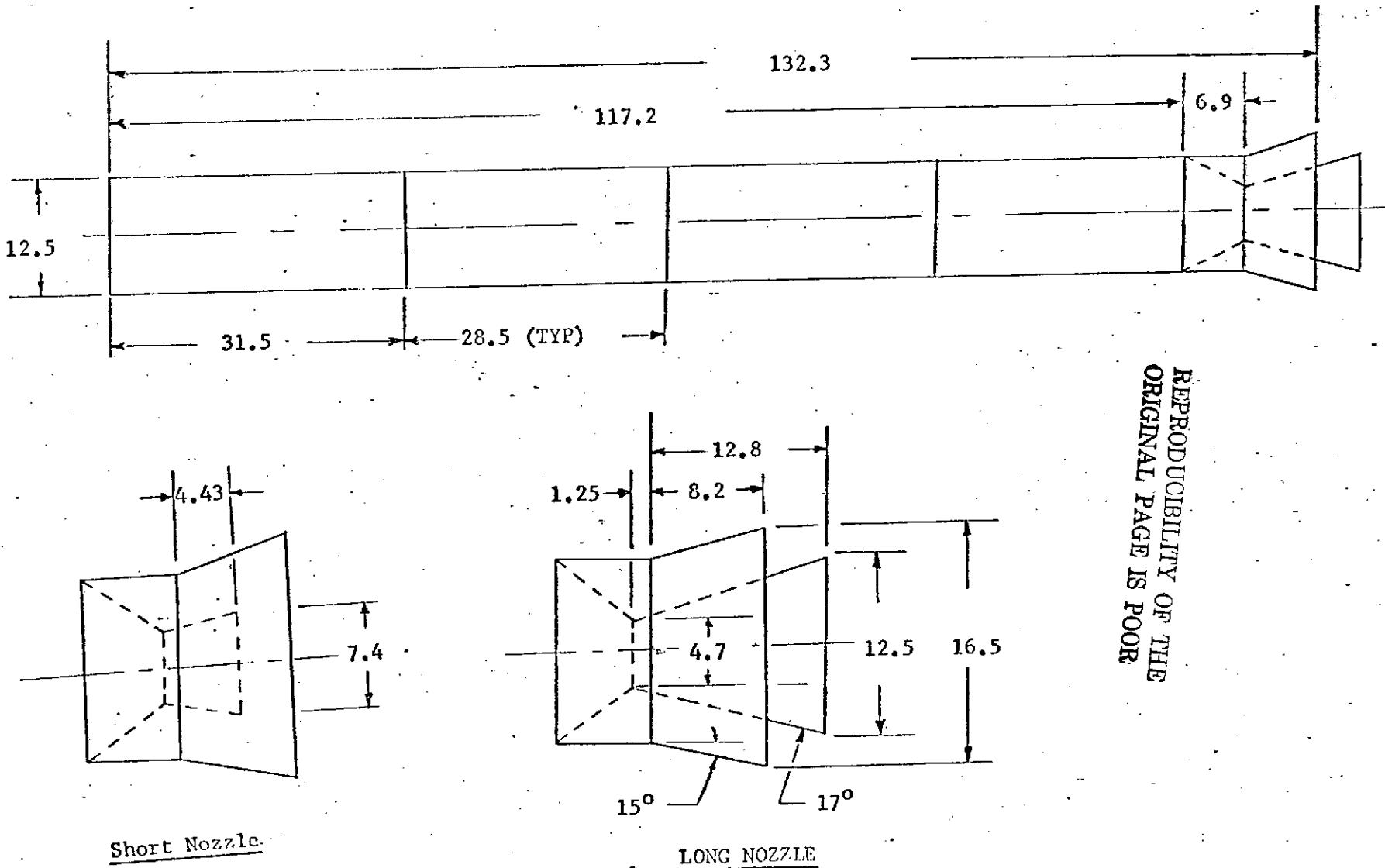


FIGURE 2. MODEL DIMENSIONS

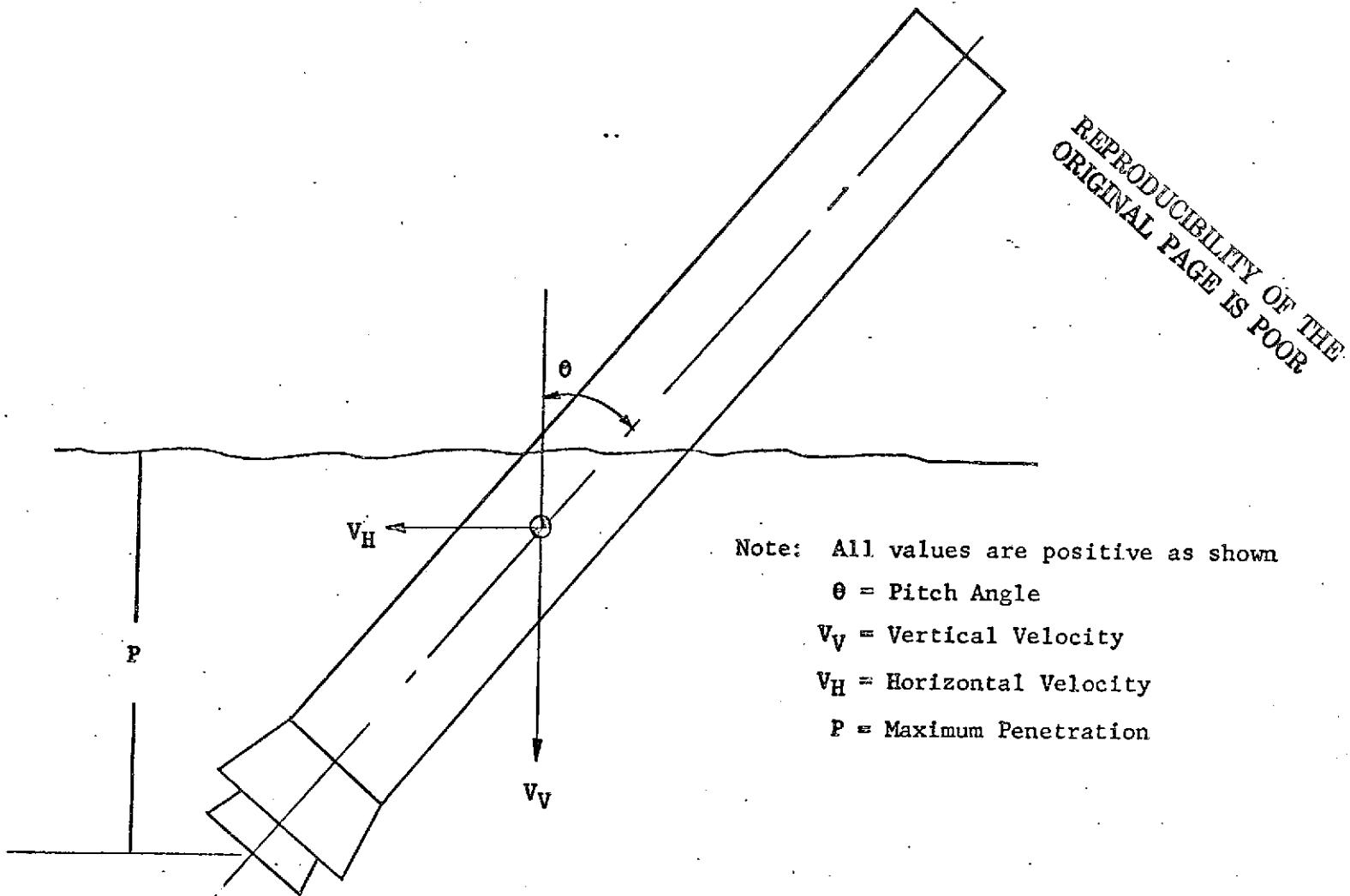
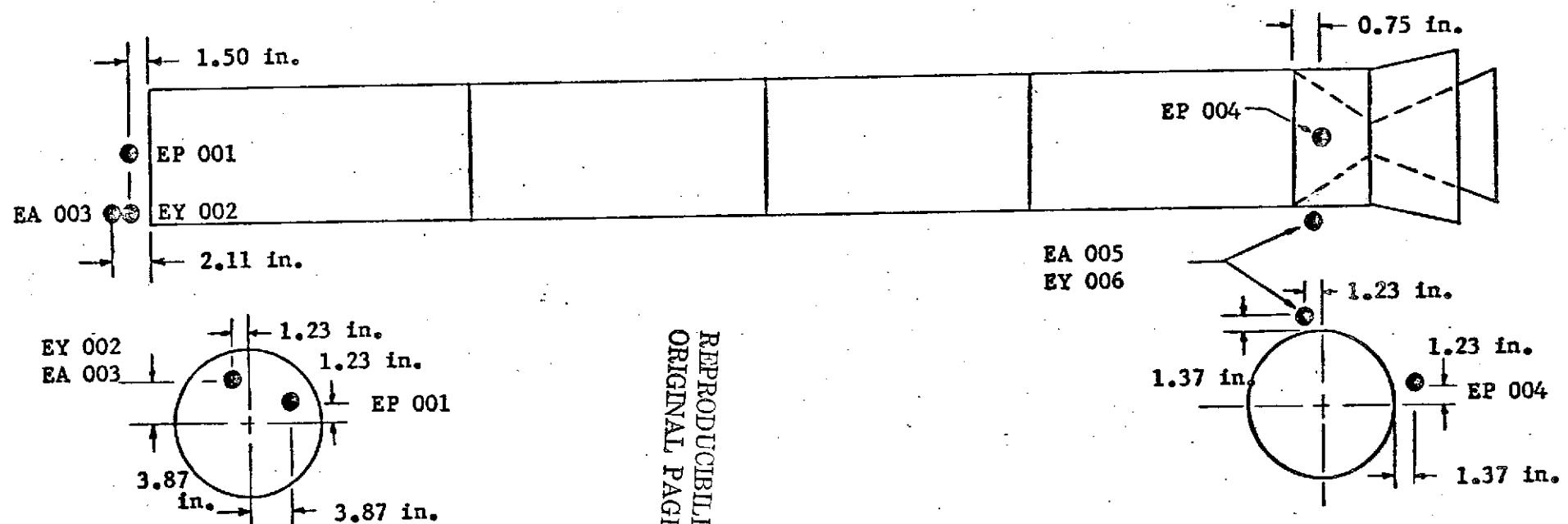


FIGURE 3. MODEL COORDINATE SYSTEM AND PARAMETER DEFINITION



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FIGURE 4. 12.5-INCH SRB THERMAL MODEL ACCELEROMETER LOCATIONS

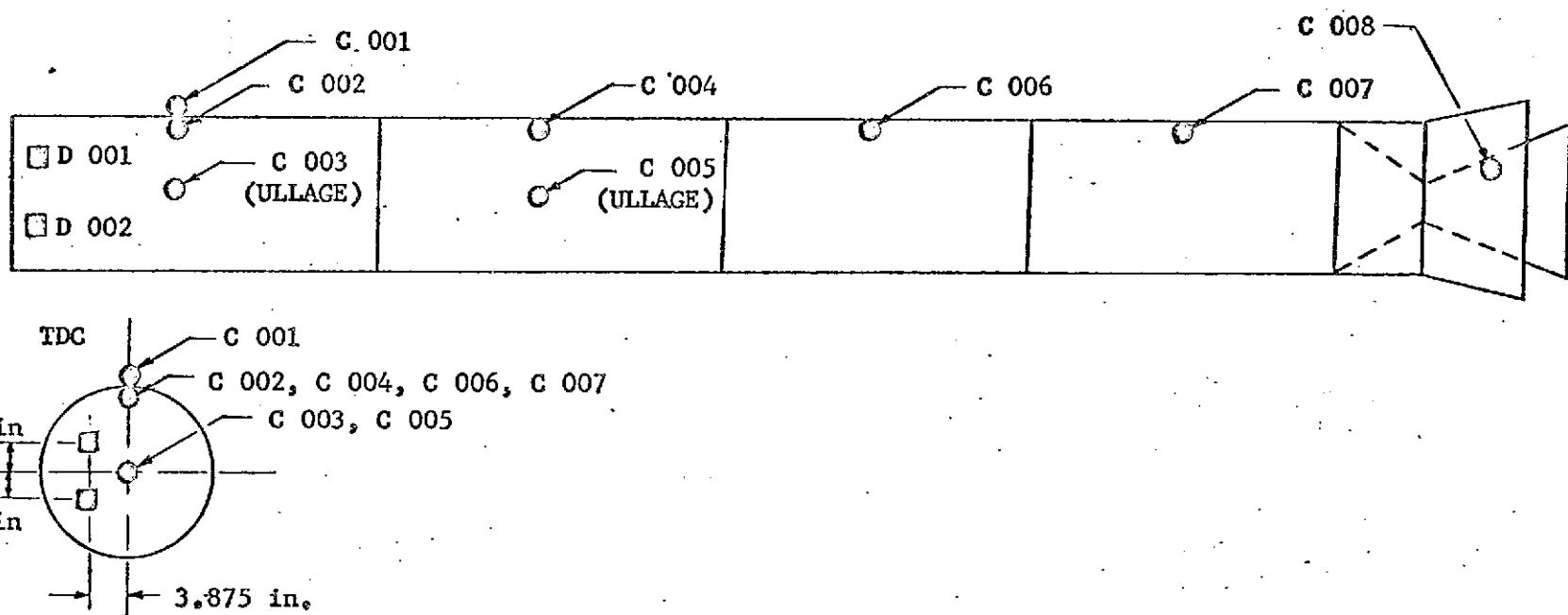


FIGURE 5. 12.5-INCH THERMAL SRB MODEL PRESSURE AND TEMPERATURE LOCATIONS

APPROVAL

DATA BOOK FOR 12.5-INCH DIAMETER
SRB THERMAL MODEL WATER FLOTATION TEST - 14.7 PSIA, SERIES P024

by
S. L. Allums

The information in this report has been reviewed and approved
for technical accuracy.

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APPENDIX A

IMPACT, PENETRATION AND INITIAL TEMPERATURE DATA

12.5-INCH THERMAL MODEL SRB

TABLE 1. IMPACT PARAMETERS

TEST NO.	IMPACT VELOCITY	HORIZONTAL VELOCITY	IMPACT ANGLE	ANGLE AT MAXIMUM PENETRATION	MAXIMUM PENETRATION	TIME		AVERAGE WALL ULLAGE TEMPERATURE °F
						degrees	ft / sec	
1	36.19	0	29.70	61.40	3.185/0.293			336/400
2	35.07	0.56	25.20	49.80	3.64/0.28			323/408
3	35.71	0	1.70	14.80	7.113/0.653			389/473
4	31.01	0.49	0.299	0.99	6.65/0.726			365/450
5	31.30	0	0.20	0.40	5.77/0.526			276/314
6	29.85	0	0.599	1.49	5.92/0.644			301/322
7	30.82	0	18.10	46.20	3.90/0.416			199/213
8	30.95	0	18.50	48.60	3.95/0.440			303/348
9	30.40	0.36	18.40	59.70	4.21/0.461			381/424
10	35.87	0.40	17.40	54.80	4.44/0.510			400/422
11	24.45	1.19	17.80	47.70	4.52/0.473			414/465
12	15.44	0.25	18.7	41.40	3.98/0.489			428/476
14	29.85	0.38	28.0	61.30	3.65/0.363			250/276
15	30.14	0.38	27.30	60.20	3.72/0.355			305/359
16	24.19	0.50	28.20	60.70	2.93/0.40			249/290
17	36.04	0.21	26.40	51.90	3.64/0.281			308/370
18	30.30	0.51	26.20	59.40	3.26/0.322			349/414
19	24.55	0.24	28.90	55.20	2.41/0.325			
20	36.26	0.25	27.90	56.40	2.75/0.238			
21	23.10	0	0.099	2.20	3.89/0.650			
22	38.28	0	1.20	10.80	4.43/0.520			
23	23.84	0	0.099	3.40	5.47/1.151			264/330
24	29.76	0	0.599	2.39	4.55/0.771			239/330
25	35.97	0	1.299	1.59	4.86/0.767			248/346

AMBIENT
TEMPERATURES

TABLE I. IMPACT PARAMETERS
(Continued)

TEST NO.	IMPACT VELOCITY	HORIZONTAL VELOCITY	IMPACT ANGLE	ANGLE AT MAXIMUM PENETRATION	MAXIMUM PENETRATION	TIME	AVERAGE WALL ULLAGE TEMPERATURE
ft/sec	ft/sec	degrees	degrees	ft	/ sec	°F	
26	23.87	0	0.339	1.40	4.18/0.767		256/345
27	24.29	0	29.40	65.70	2.32/0.375		278/325
28	29.98	0.01	29.40	61.00	2.39/0.326		264/283
29	35.55	0	27.10	55.10	2.61/0.277		282/298
30	36.35	0.51	27.20	37.50	No Data		360/420
31	24.29	0.32	25.10	62.60	3.03/0.436		372/488
34	30.30	0	0.199	3.20	5.07/0.771		344/430
35	35.23	-----	No Data	-----	-----		351/433
36	24.16	-----	No Data	-----	-----		341/423

APPENDIX B

**ACCELERATION, PRESSURE, AND
TEMPERATURE DATA**

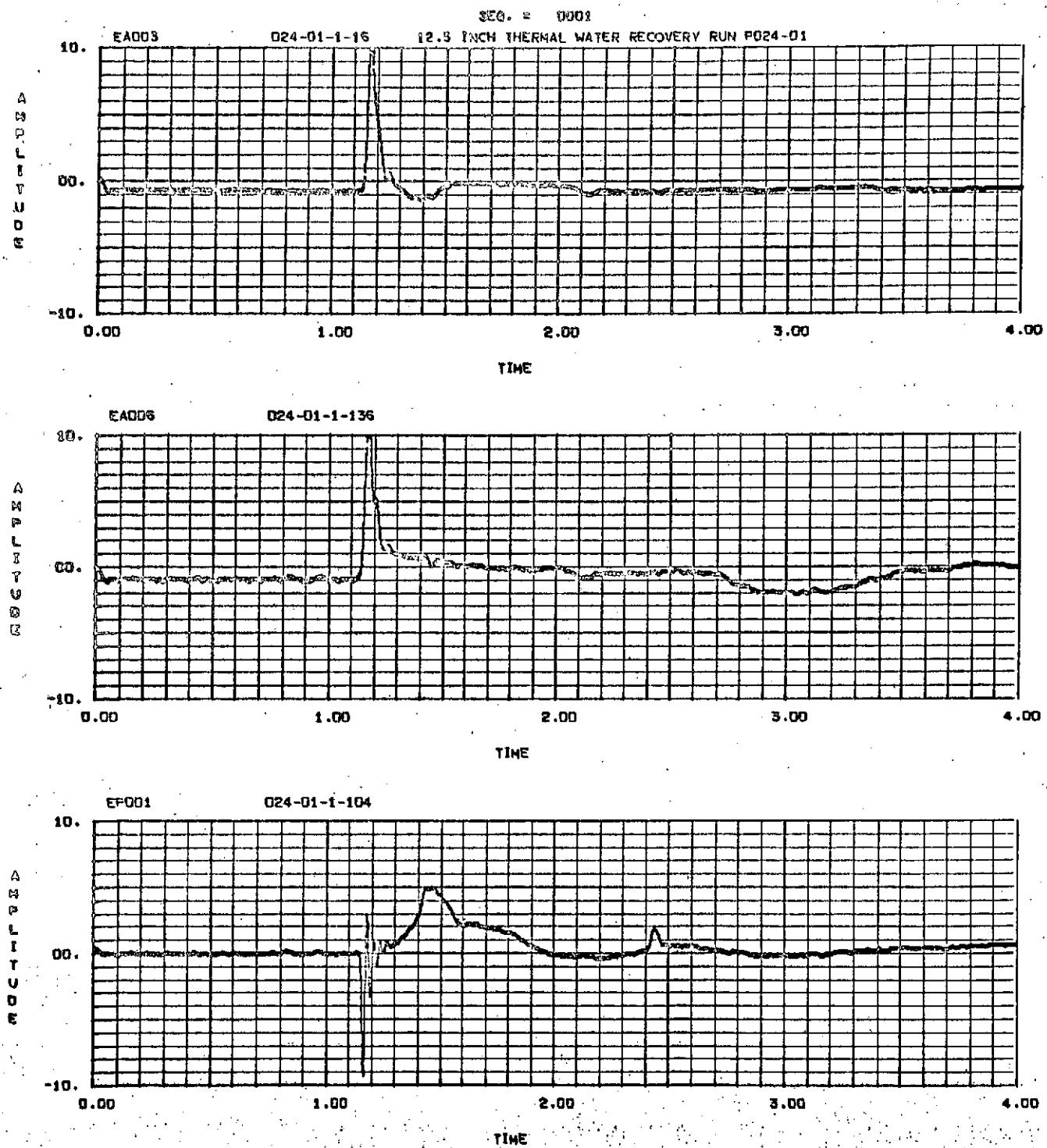
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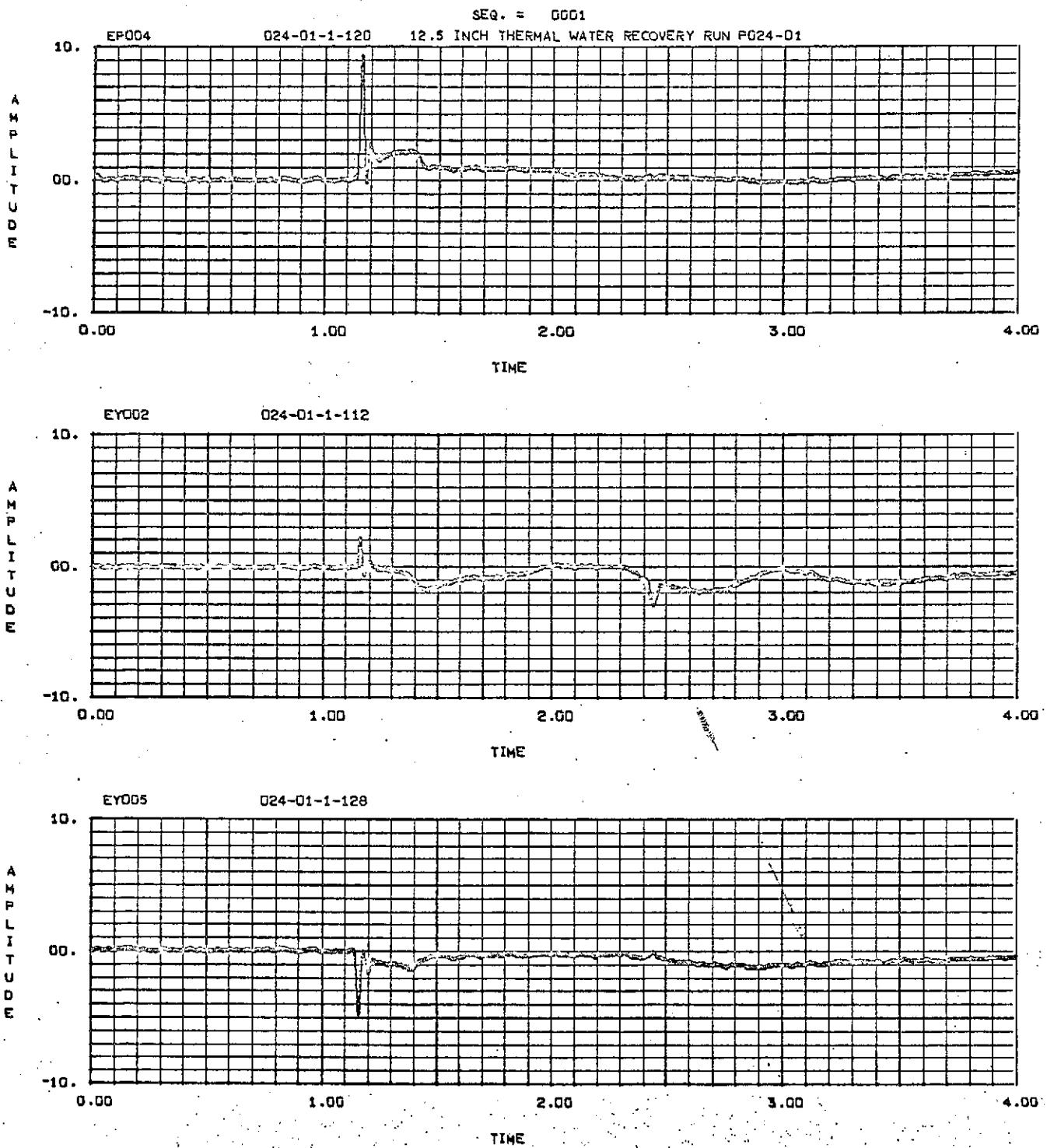
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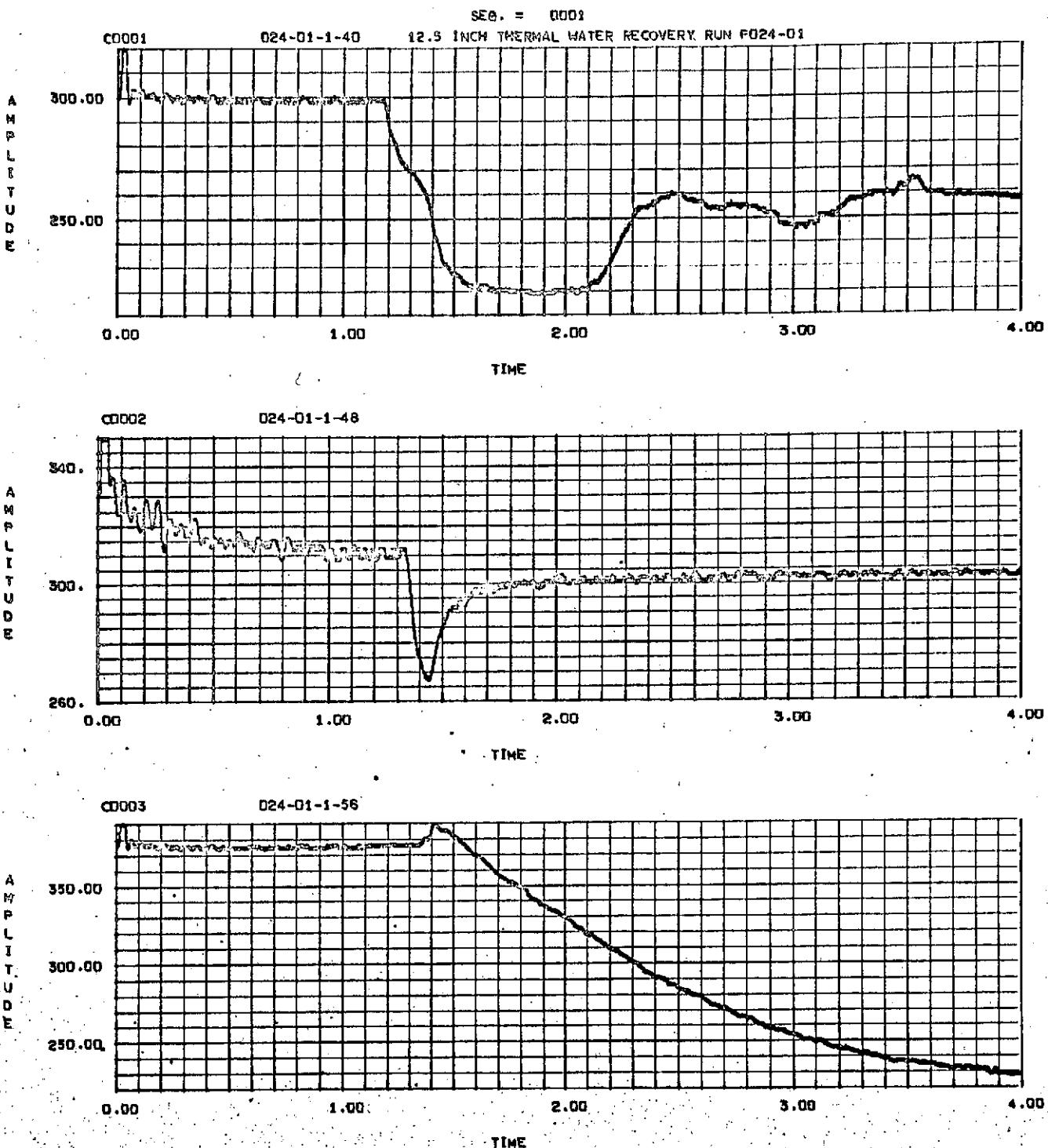
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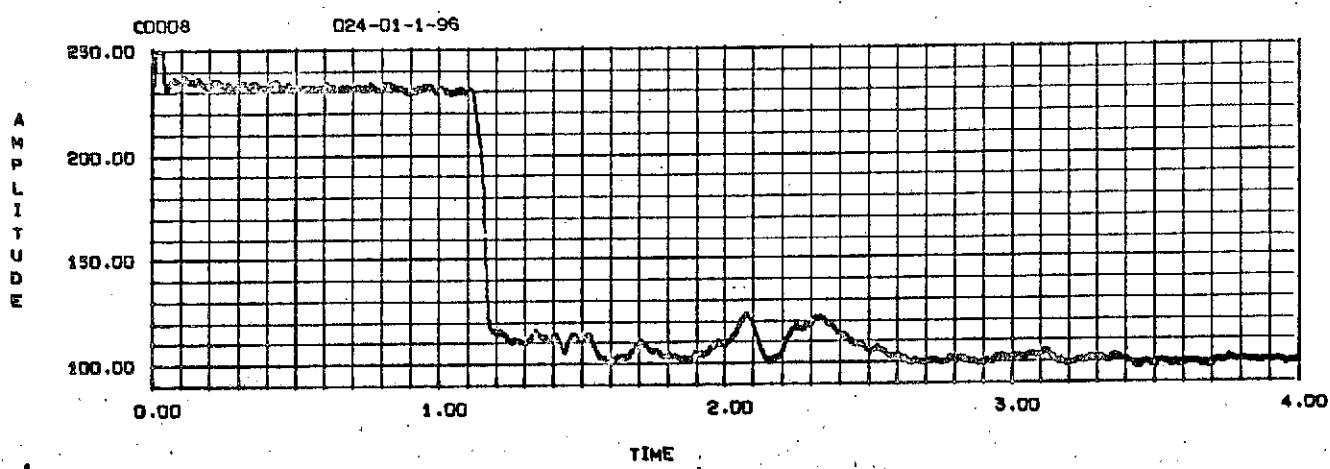
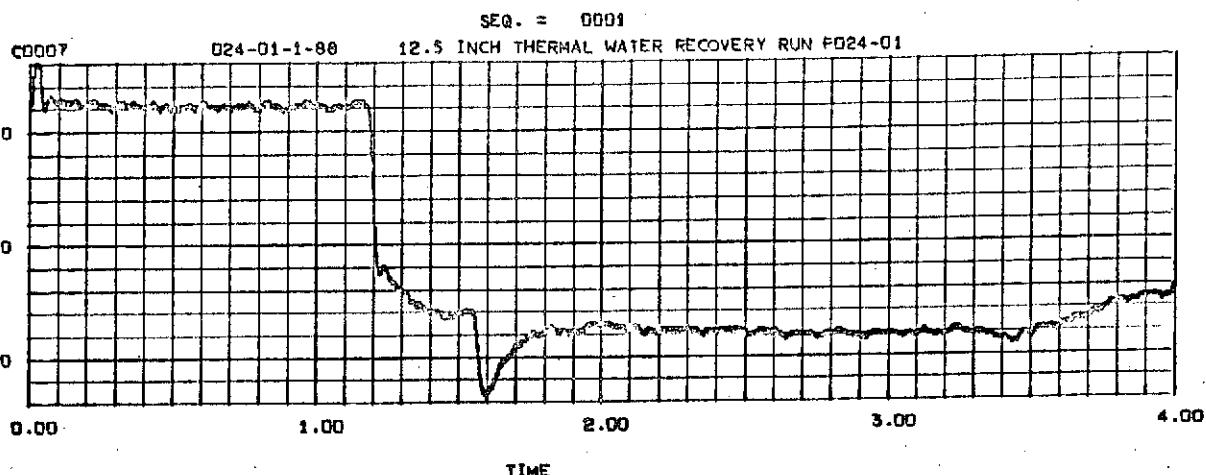
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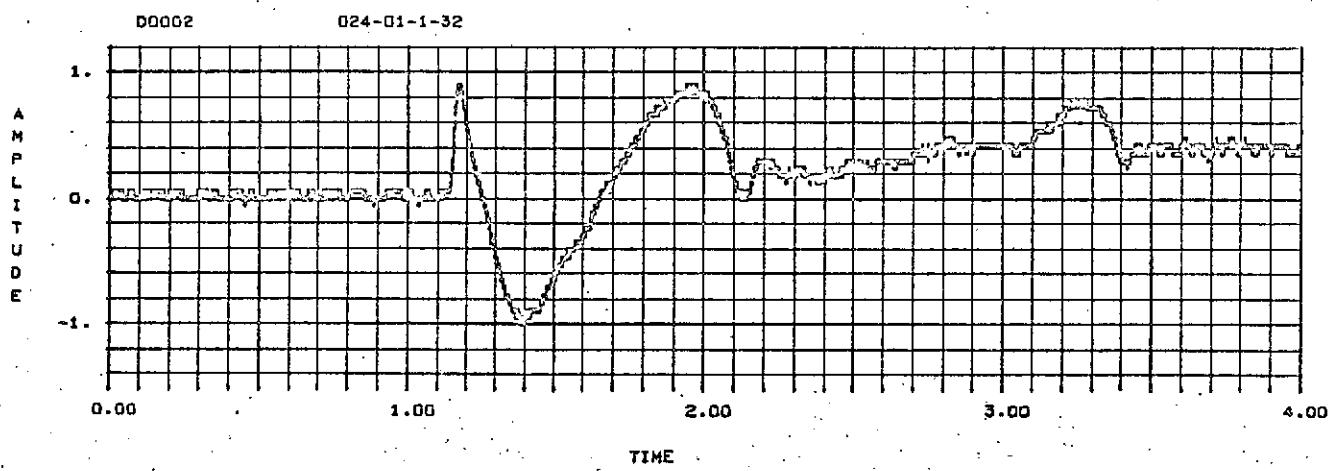
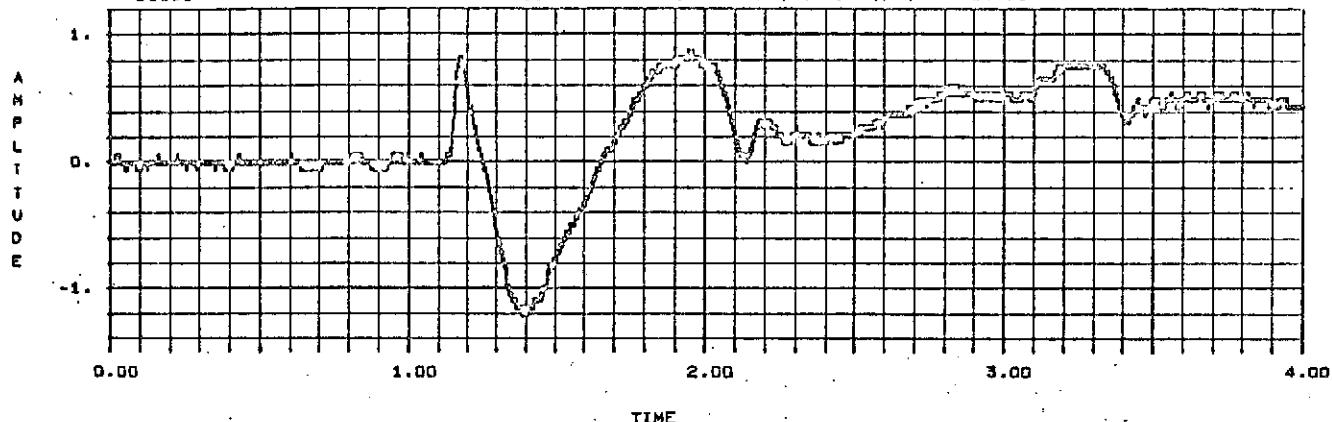
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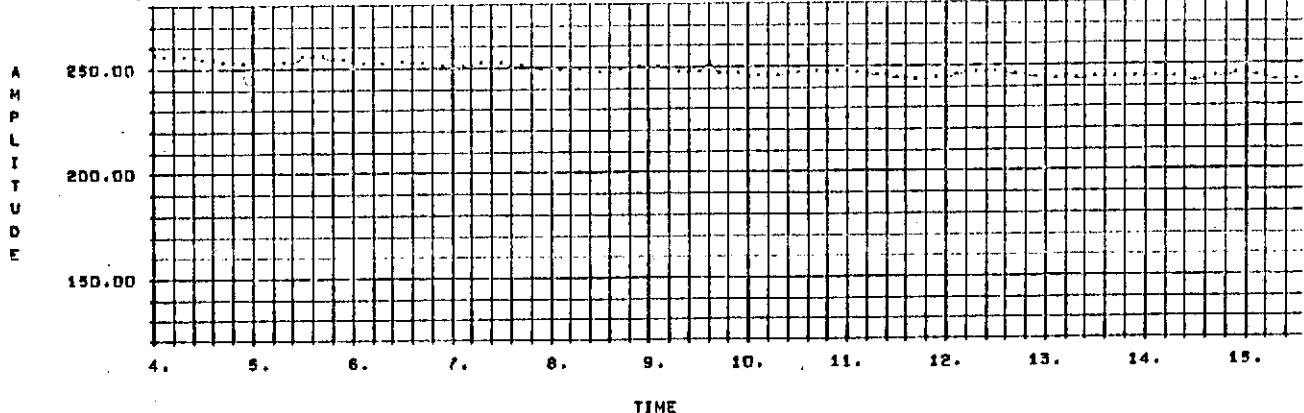
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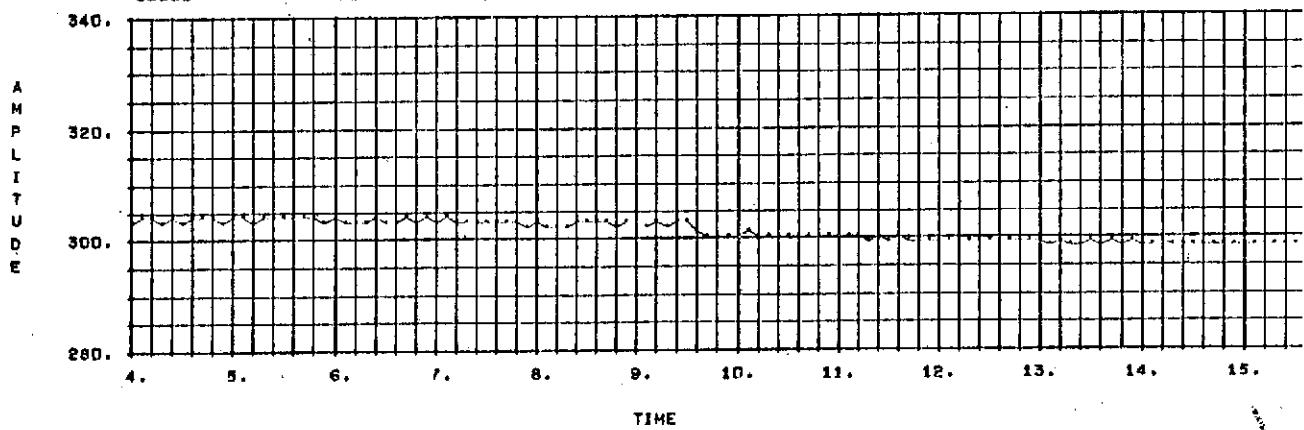


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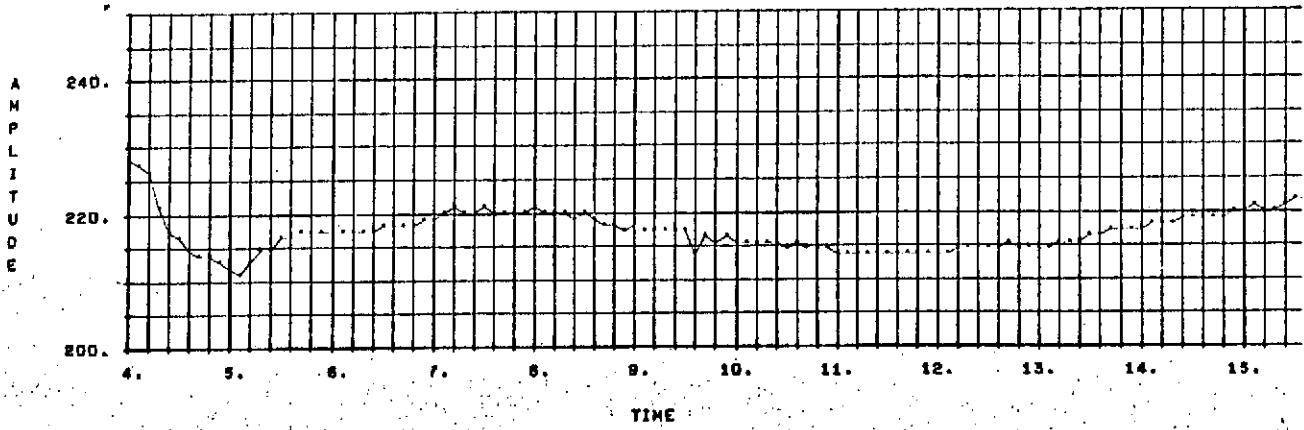
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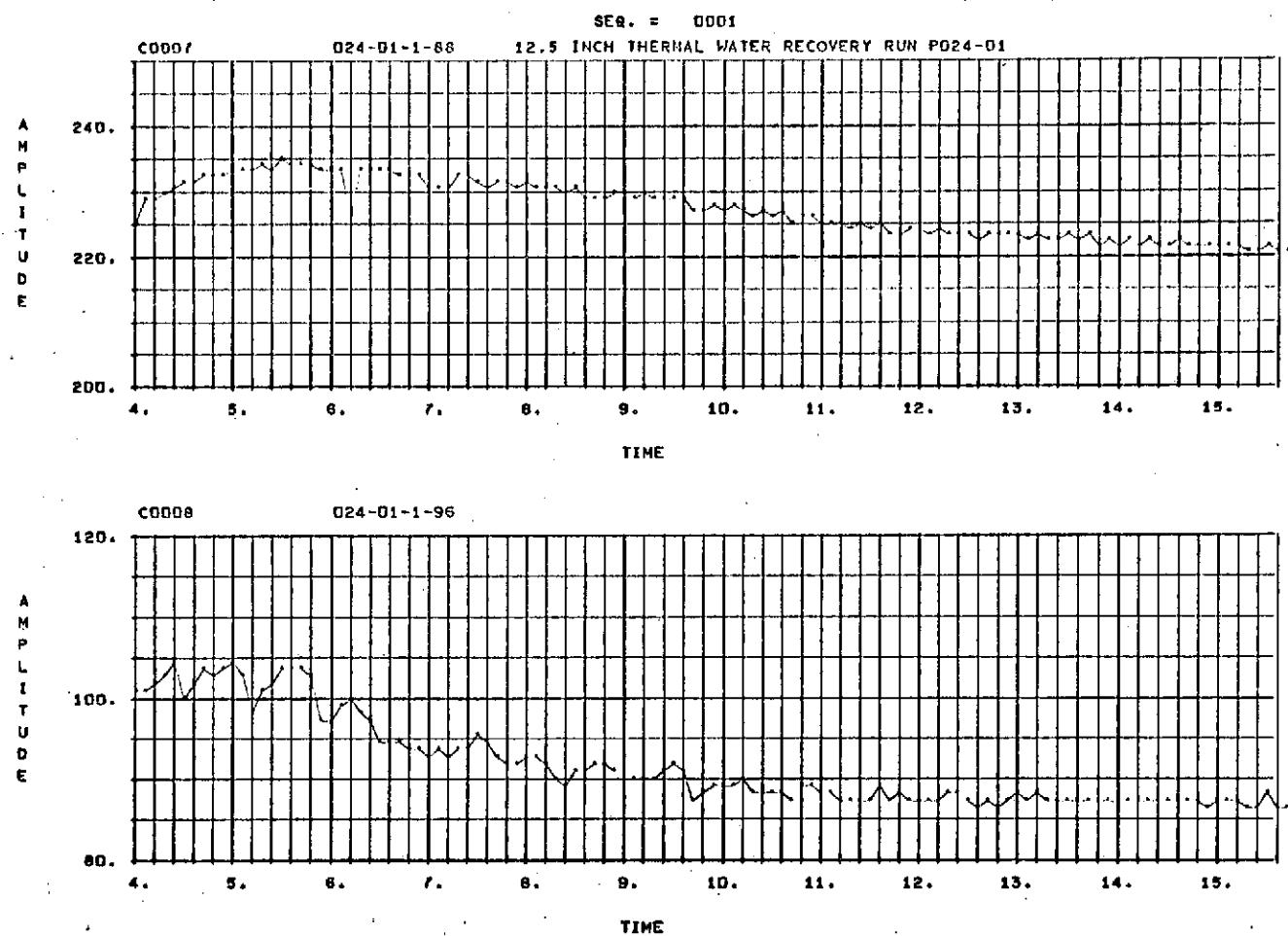
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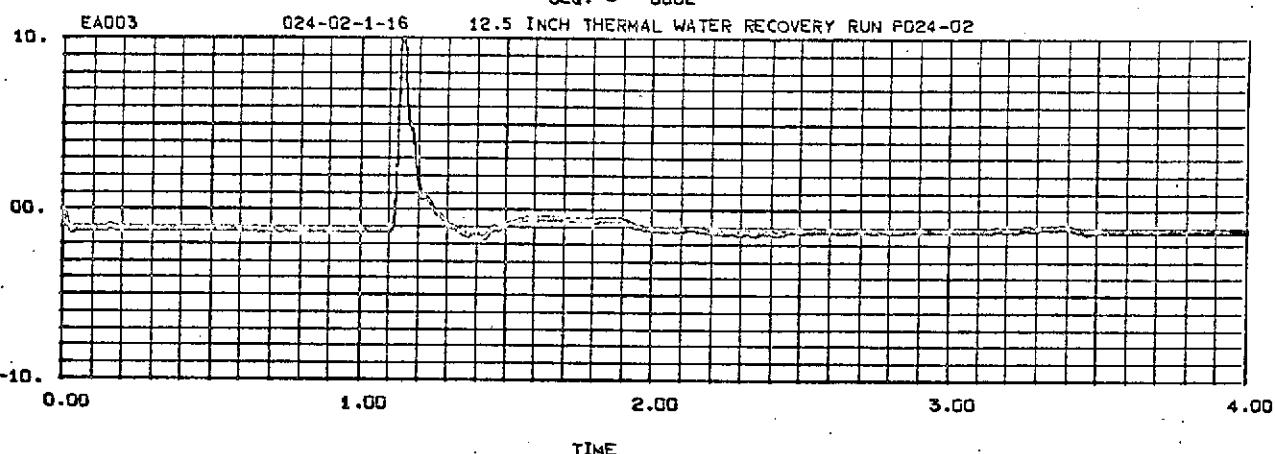
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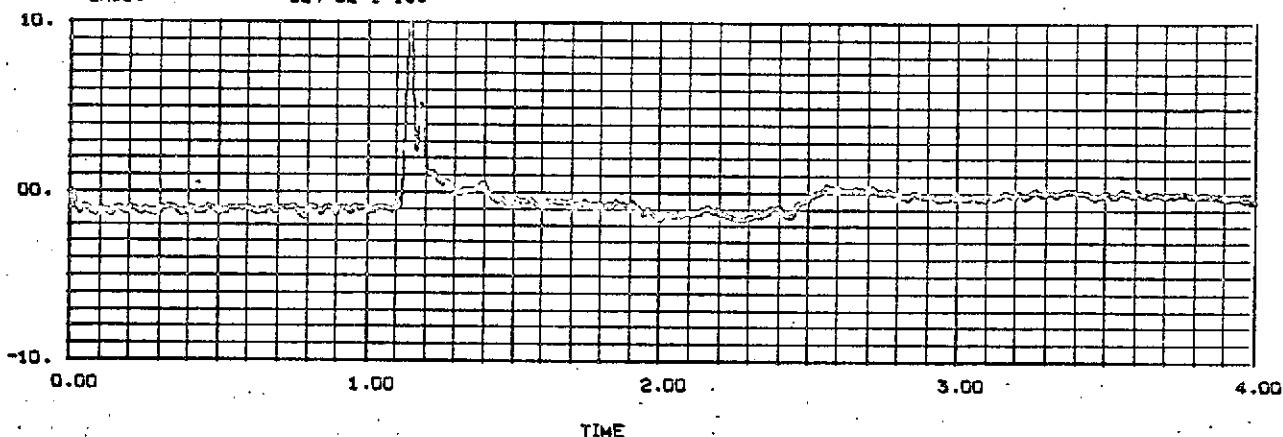


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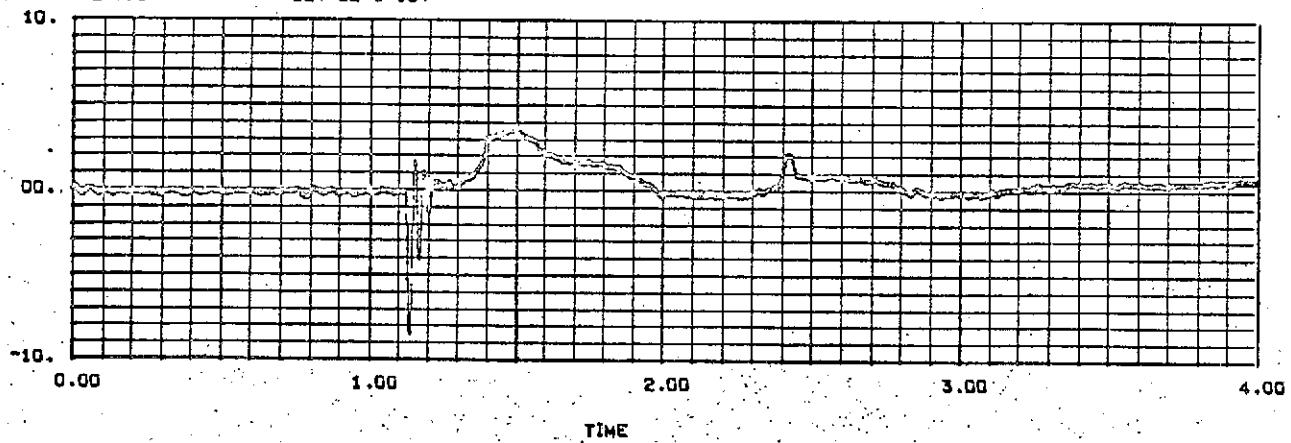
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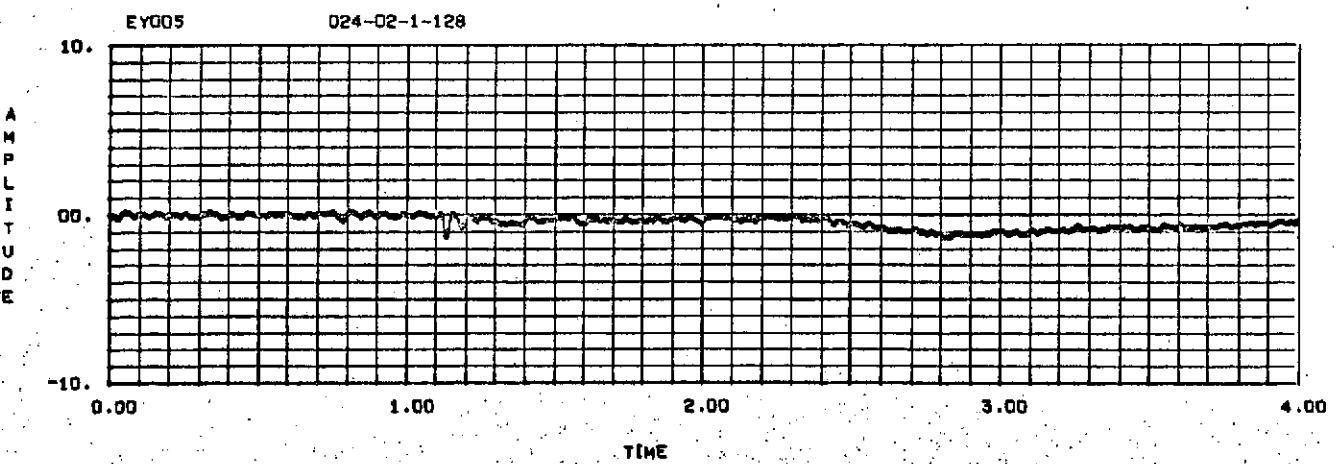
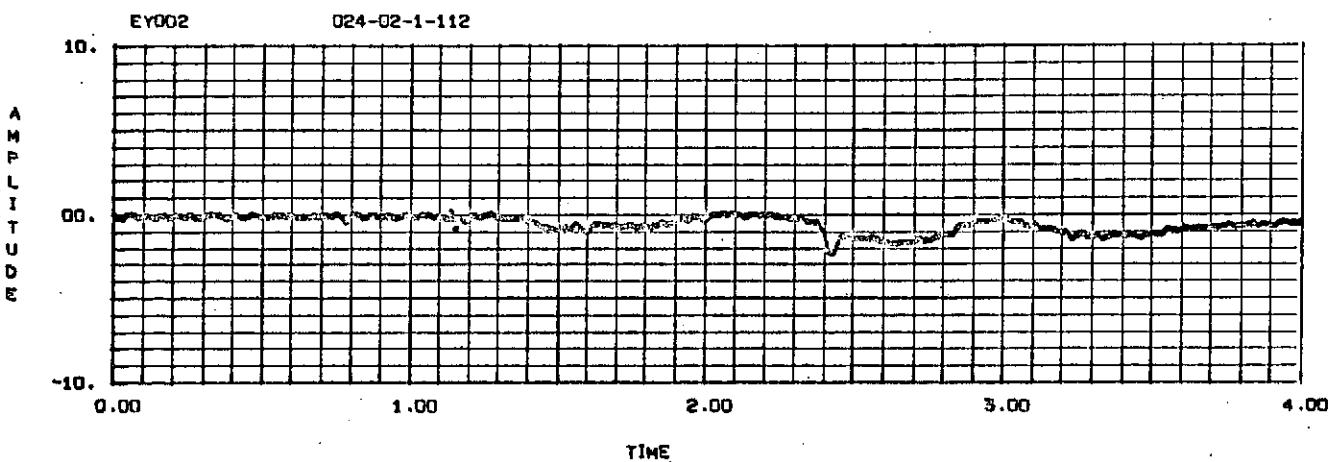
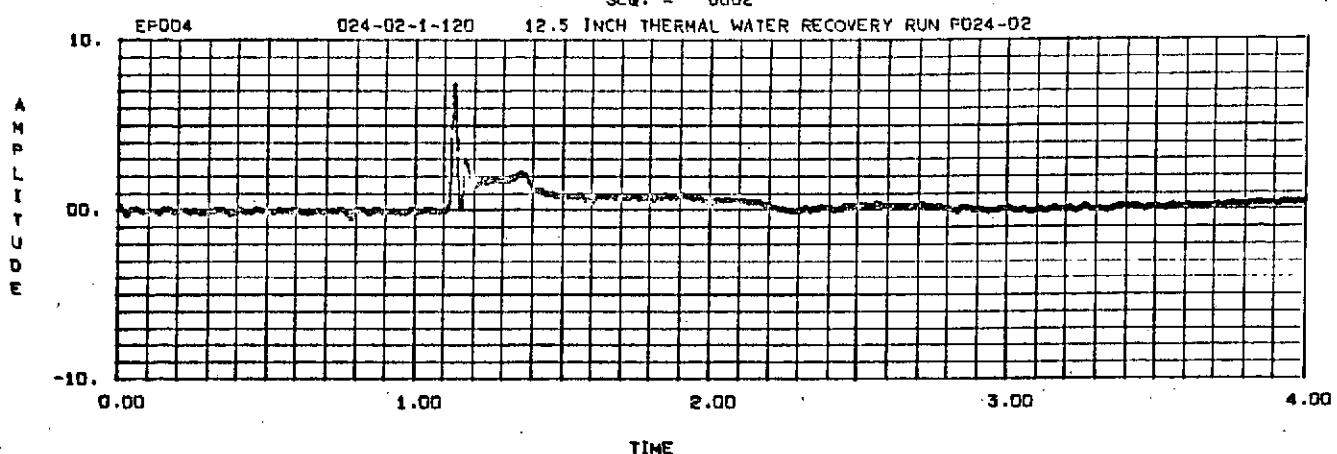
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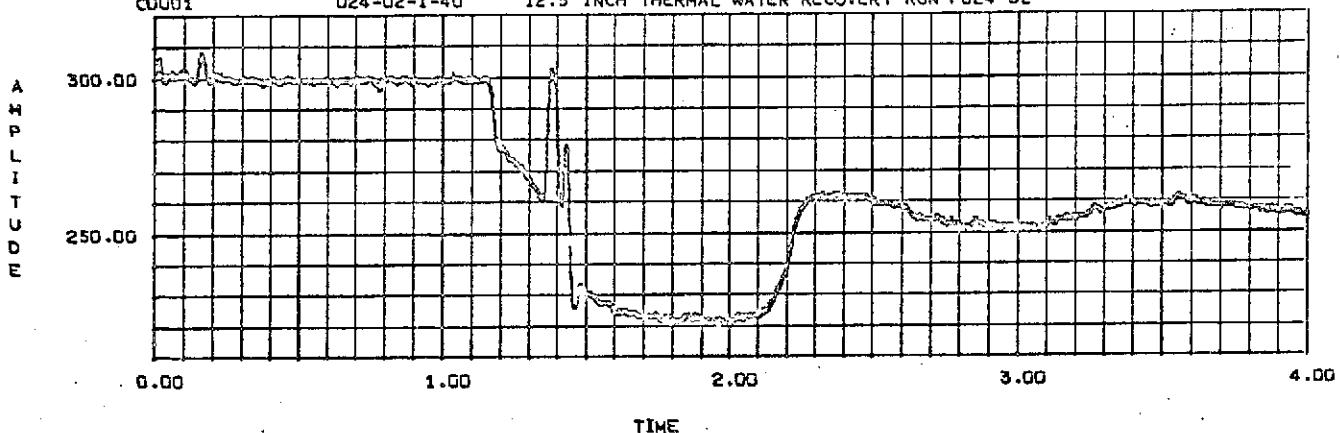
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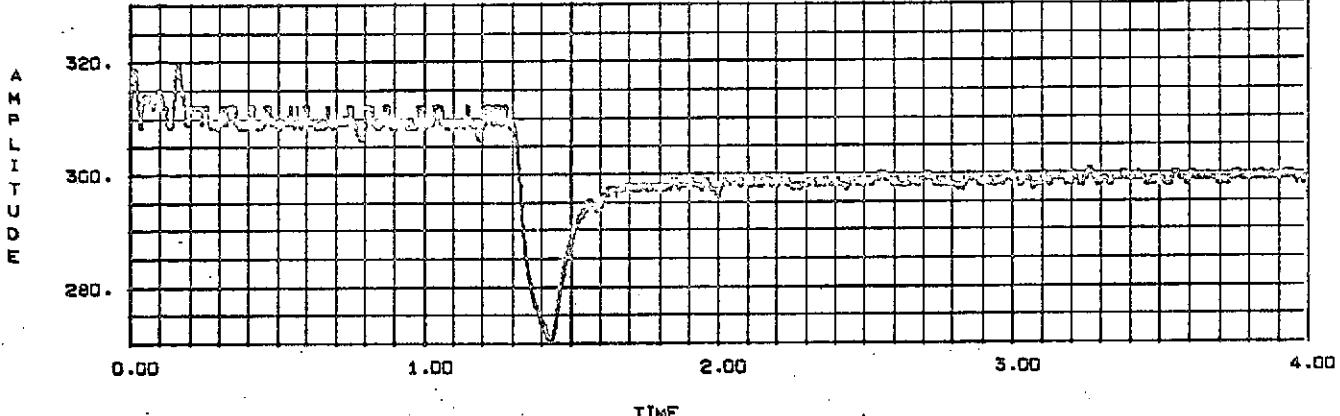
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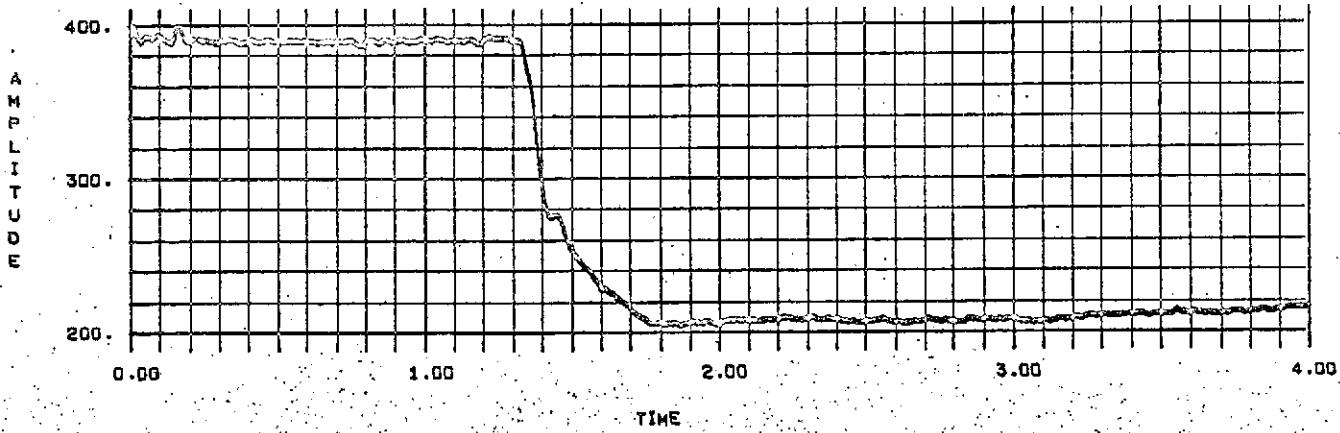
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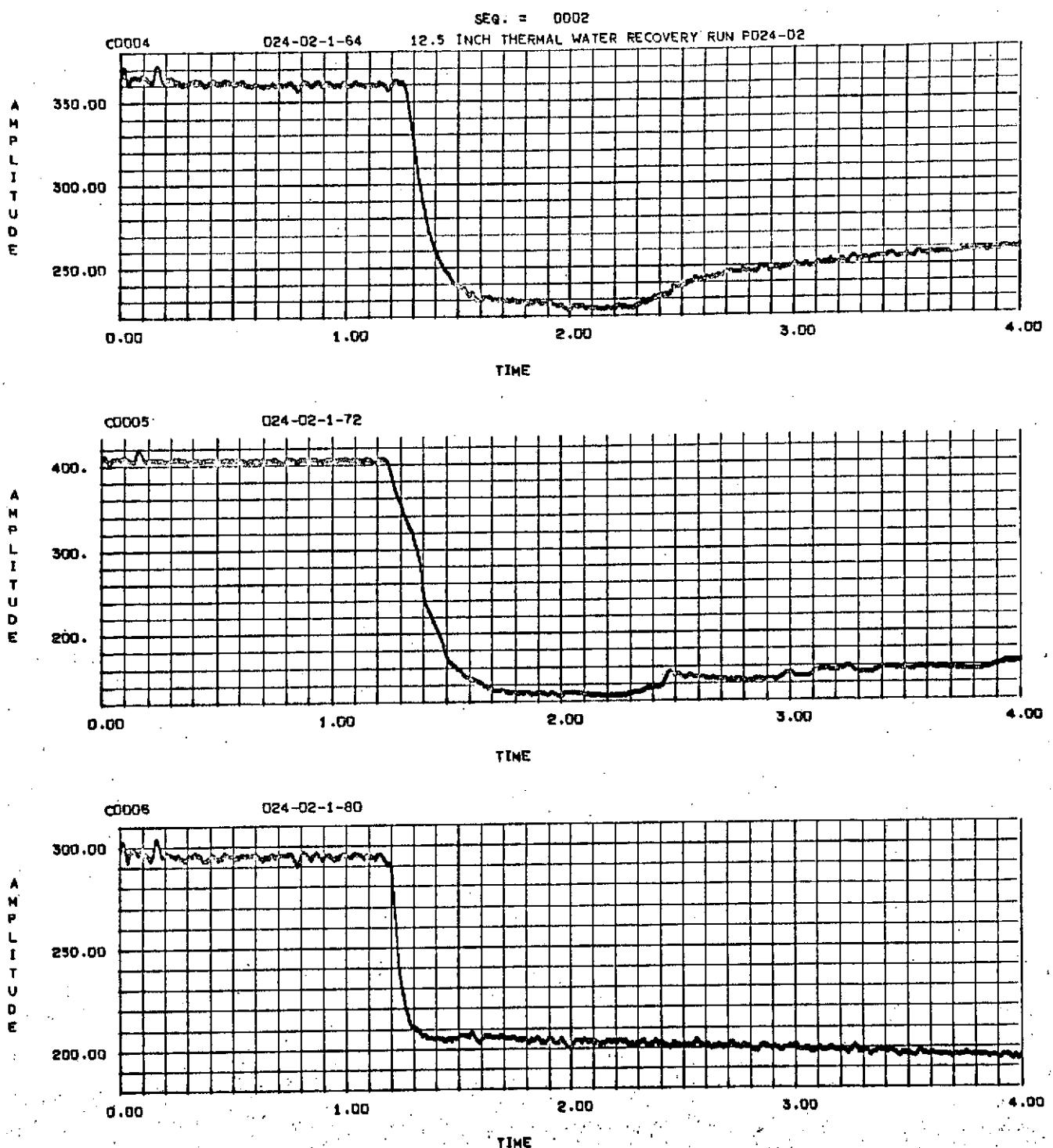


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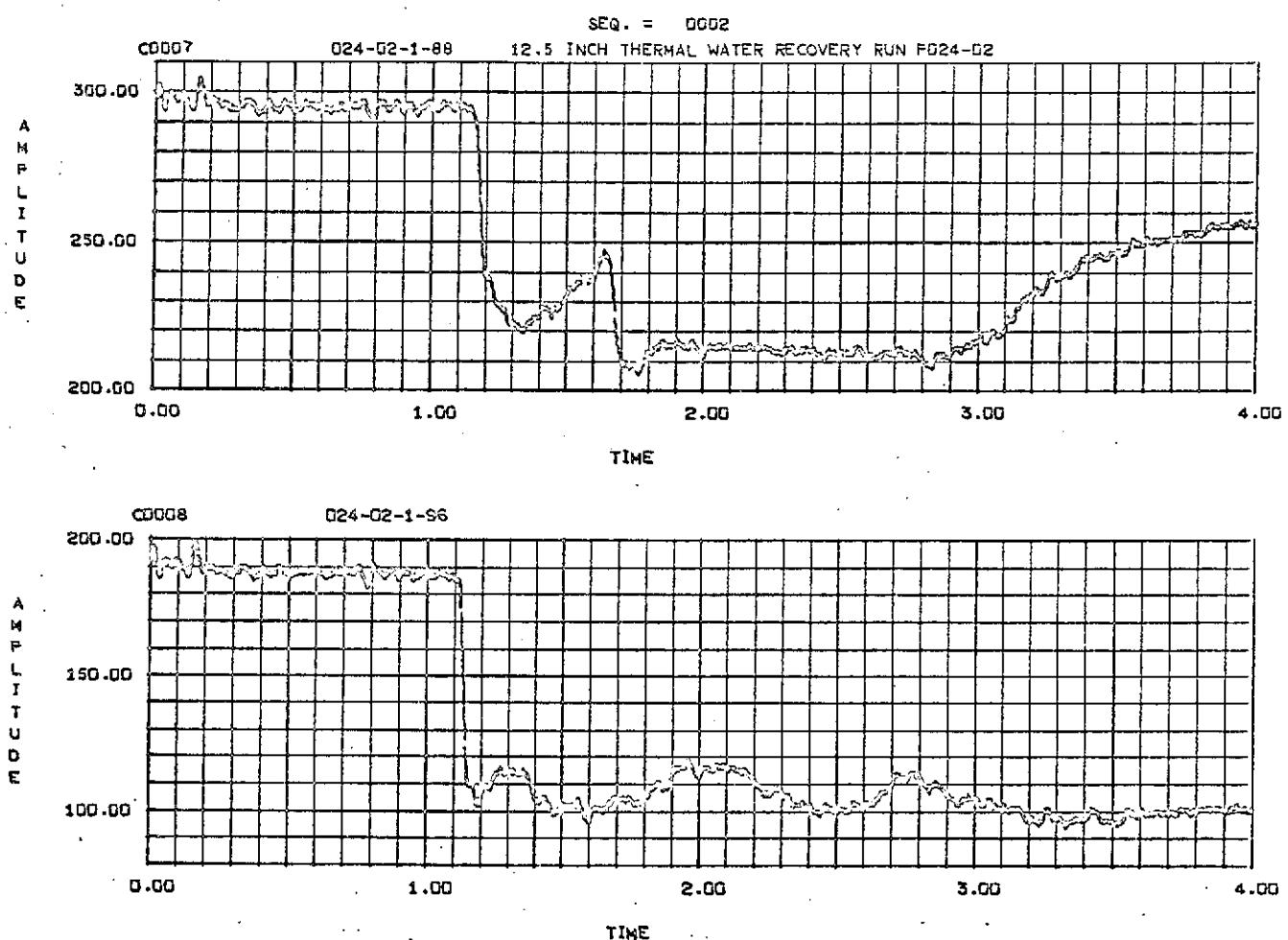


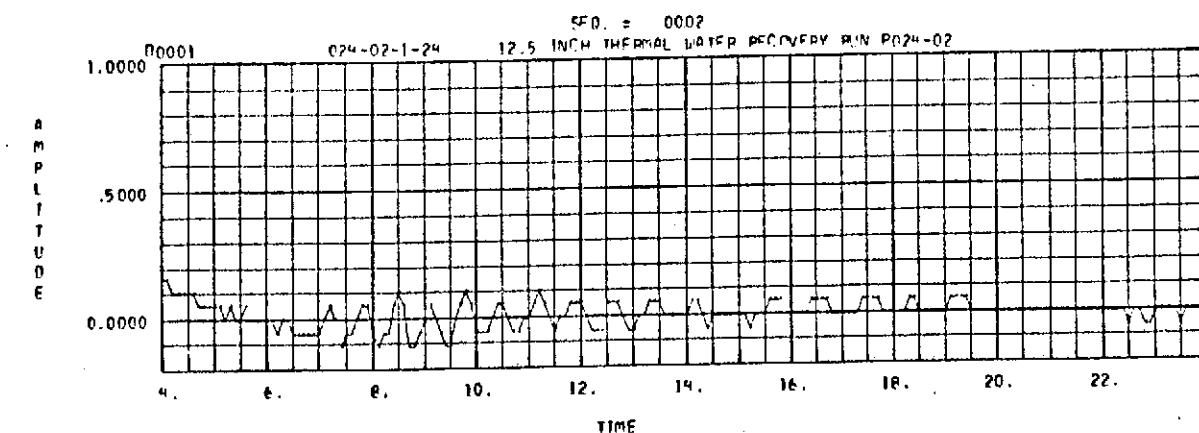
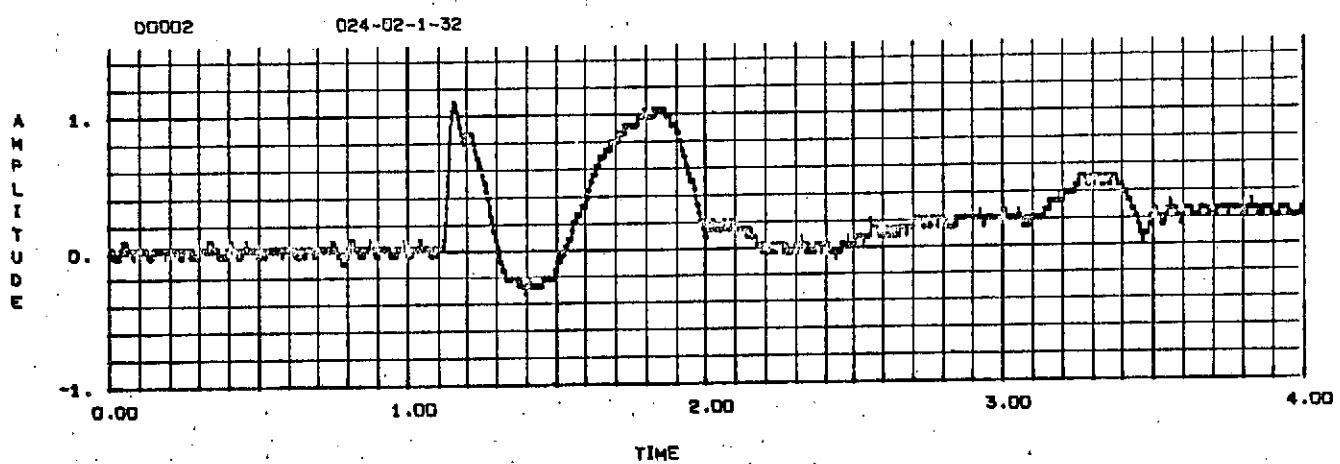
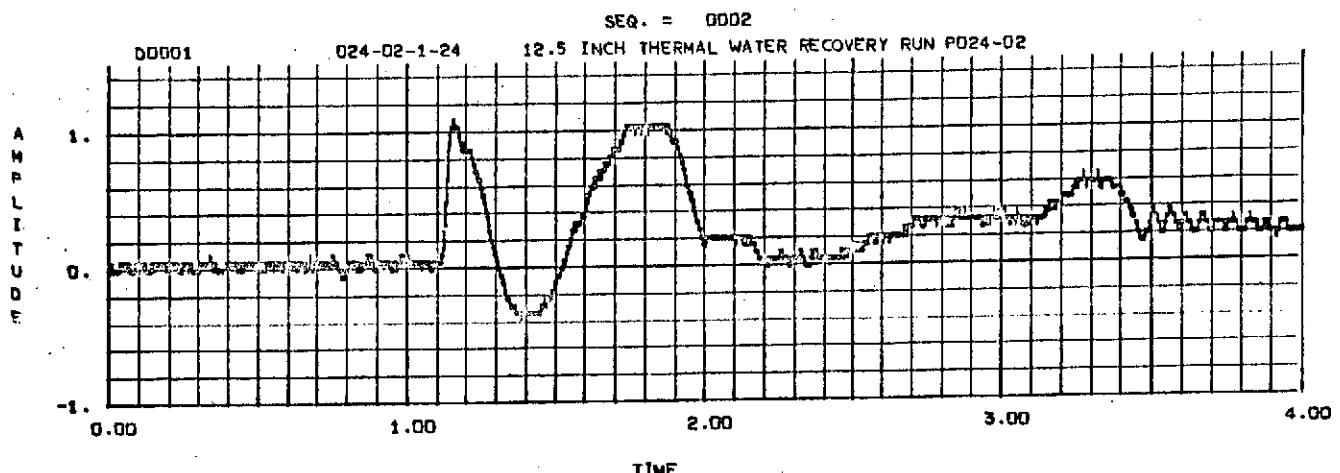
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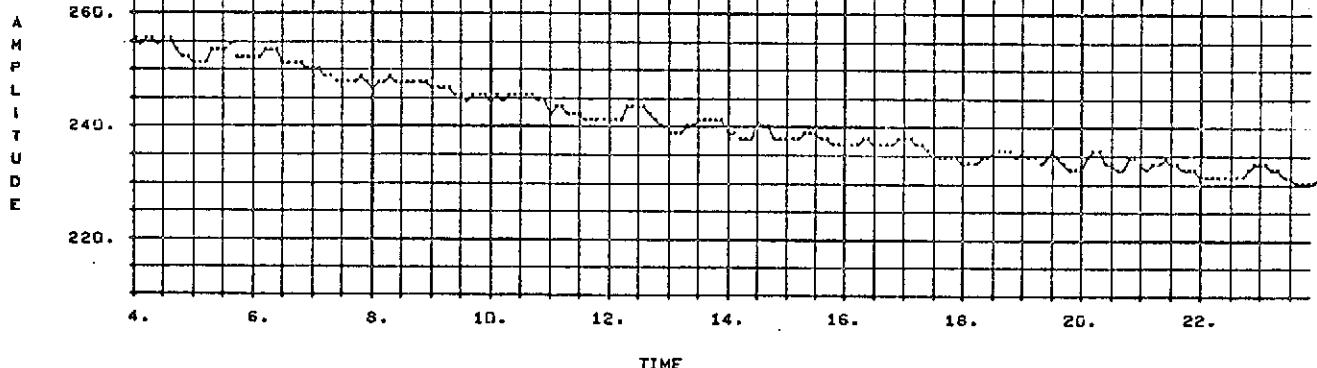
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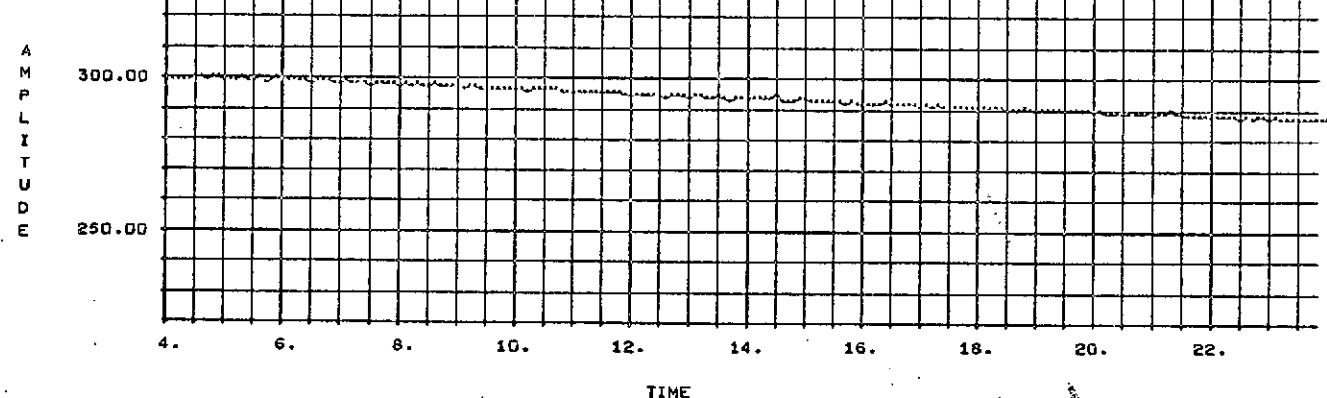


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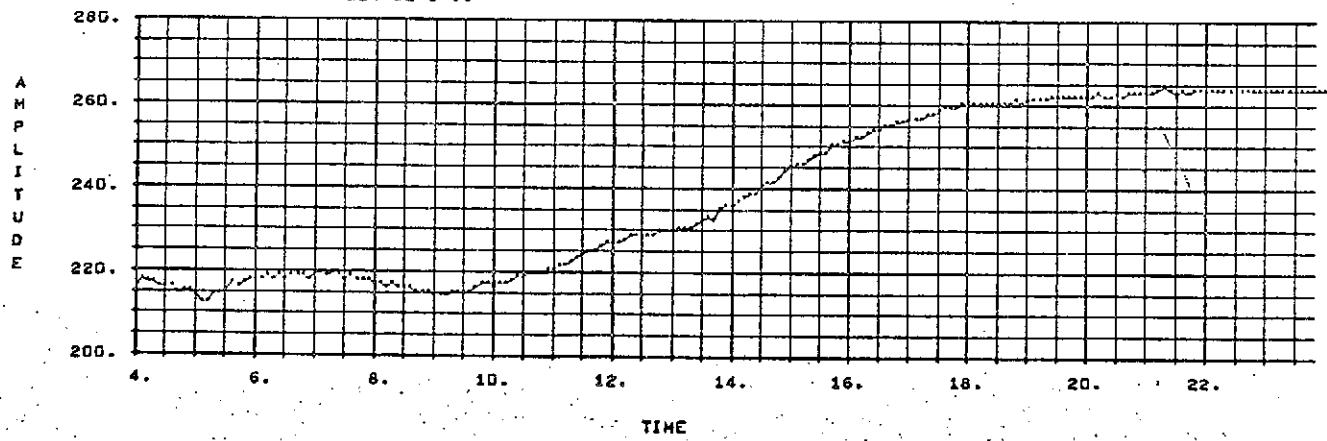
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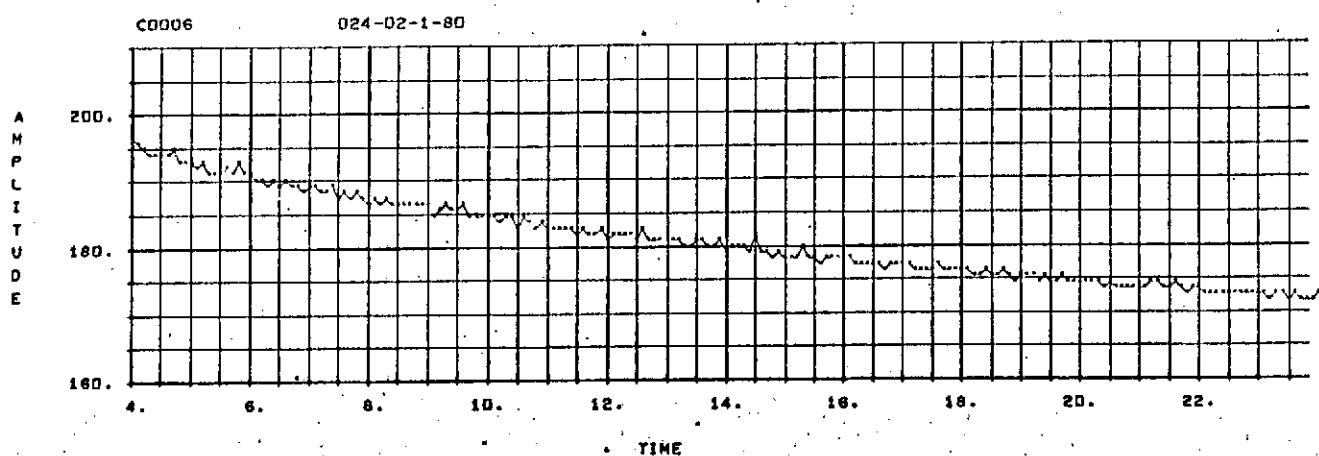
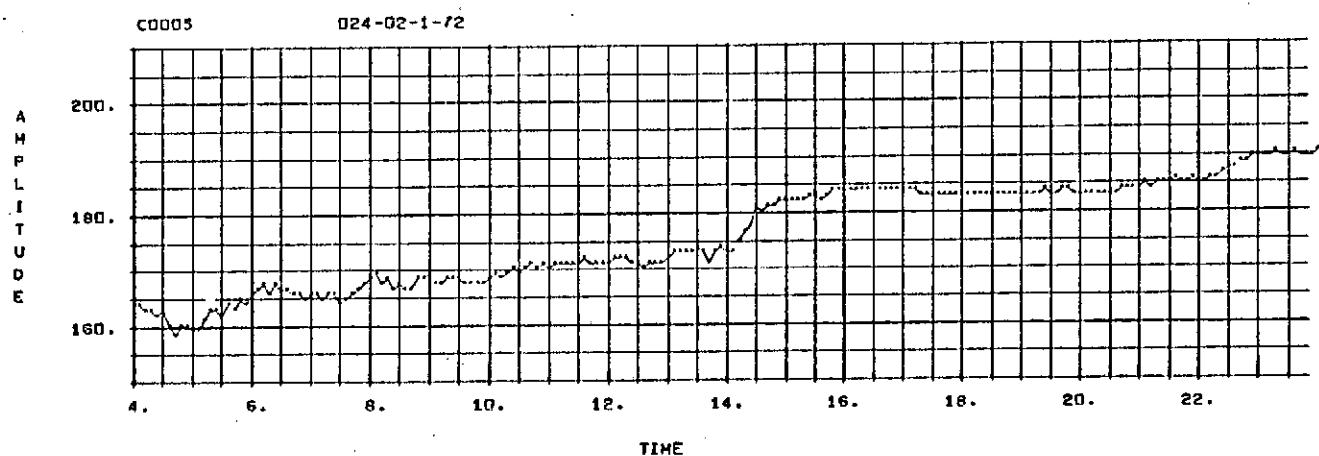
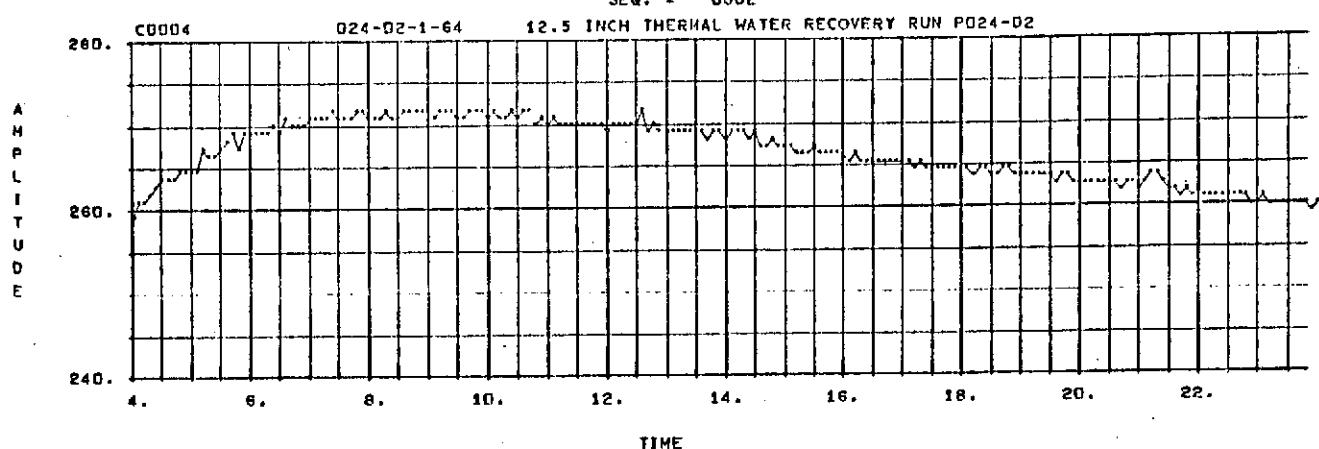
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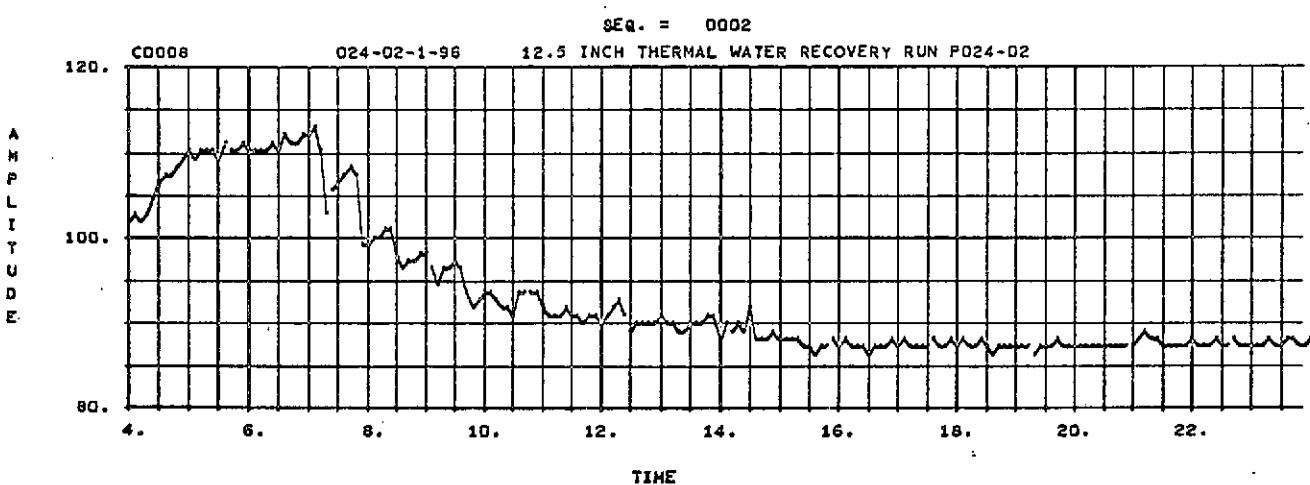
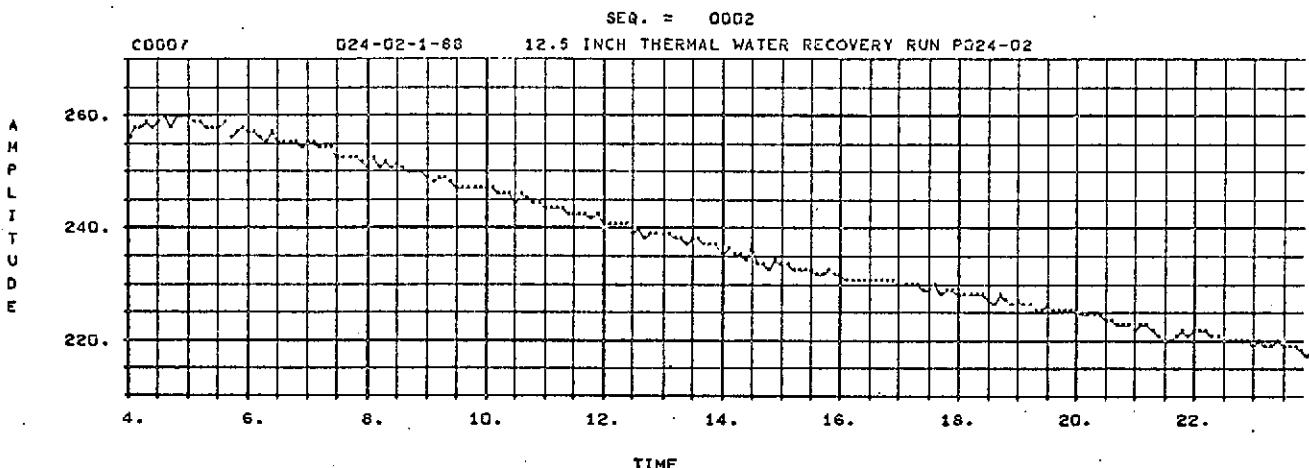
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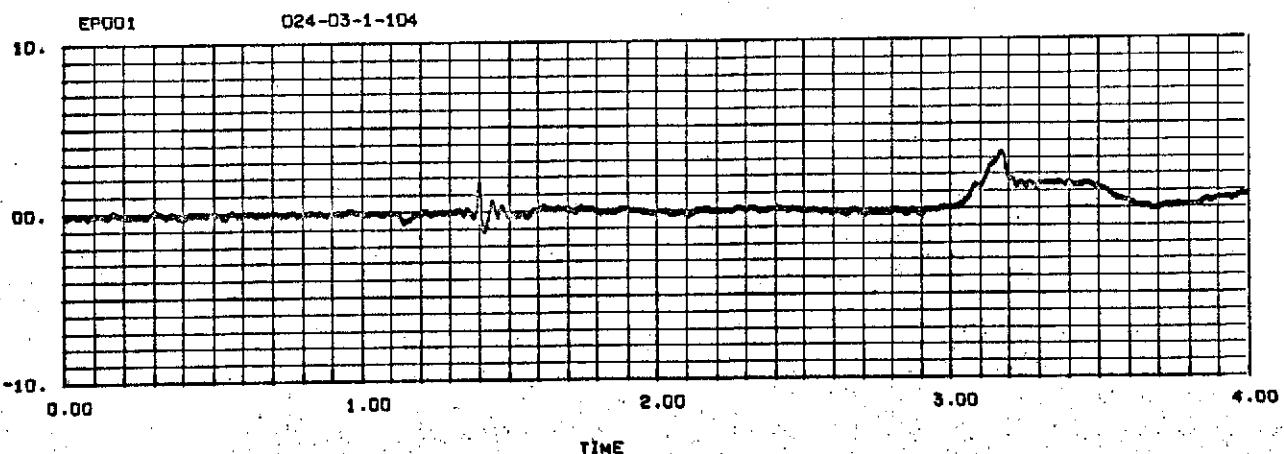
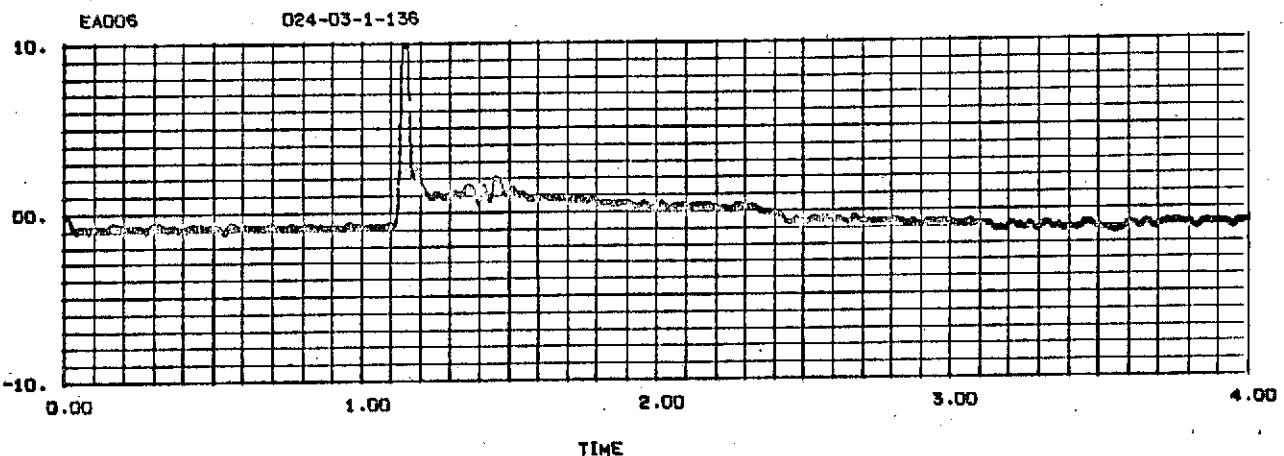
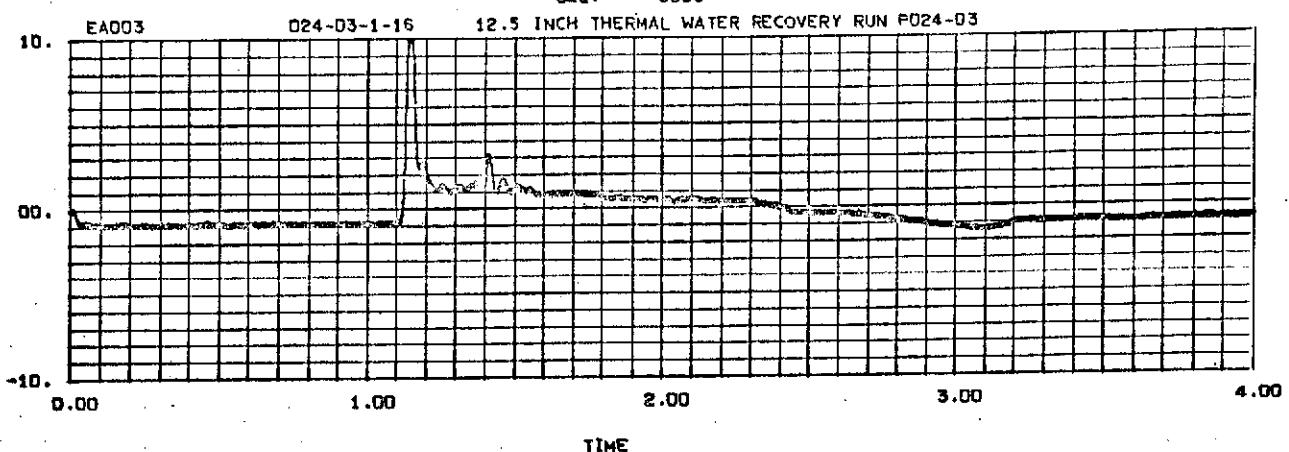
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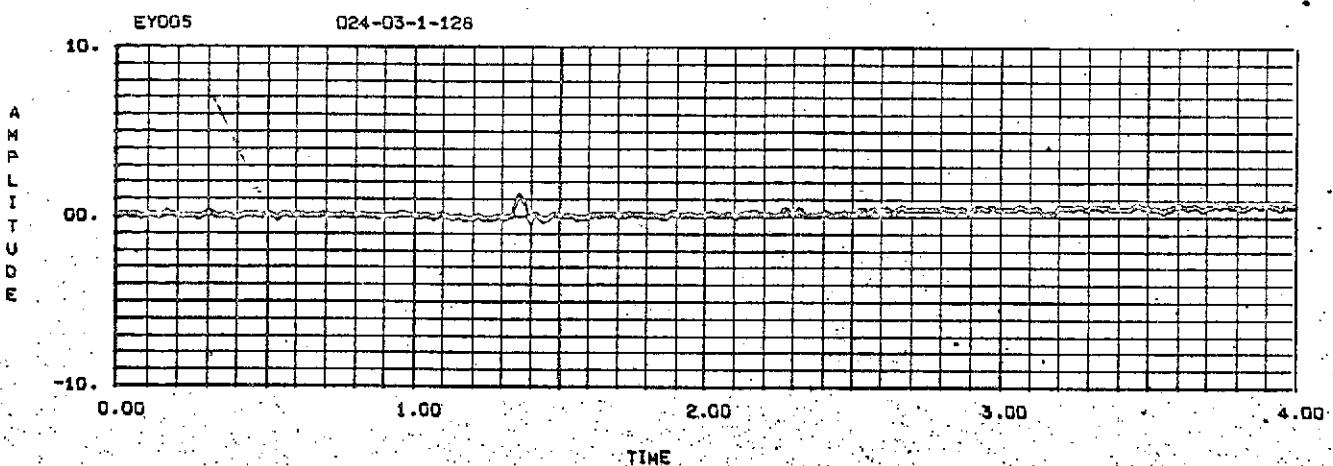
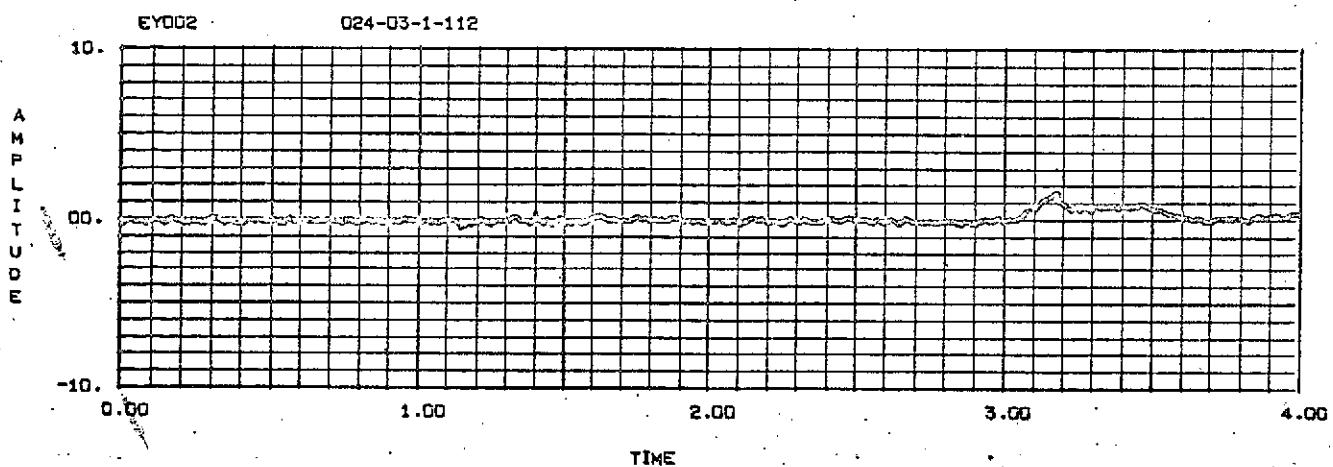
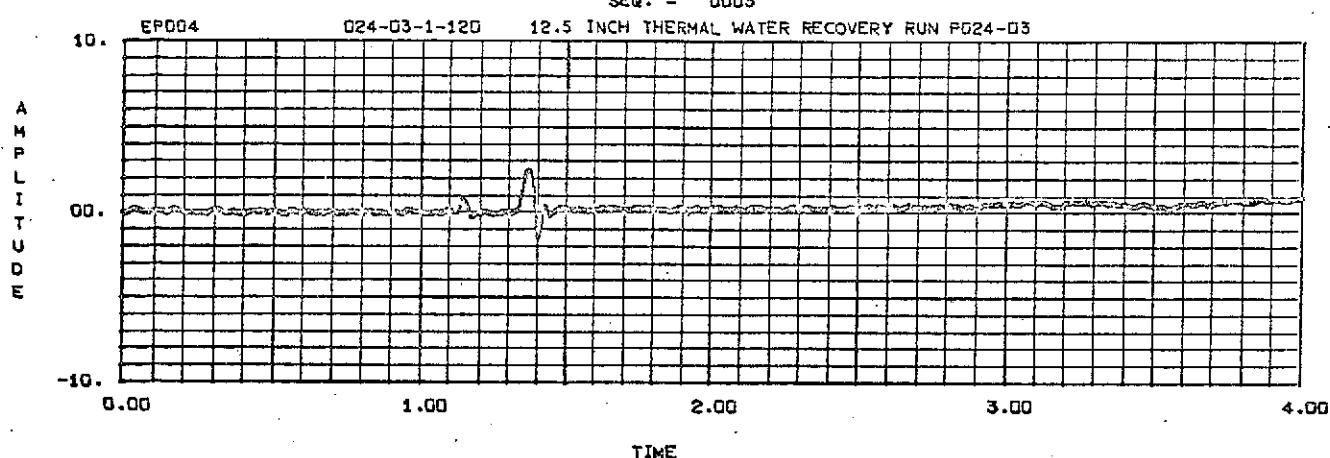


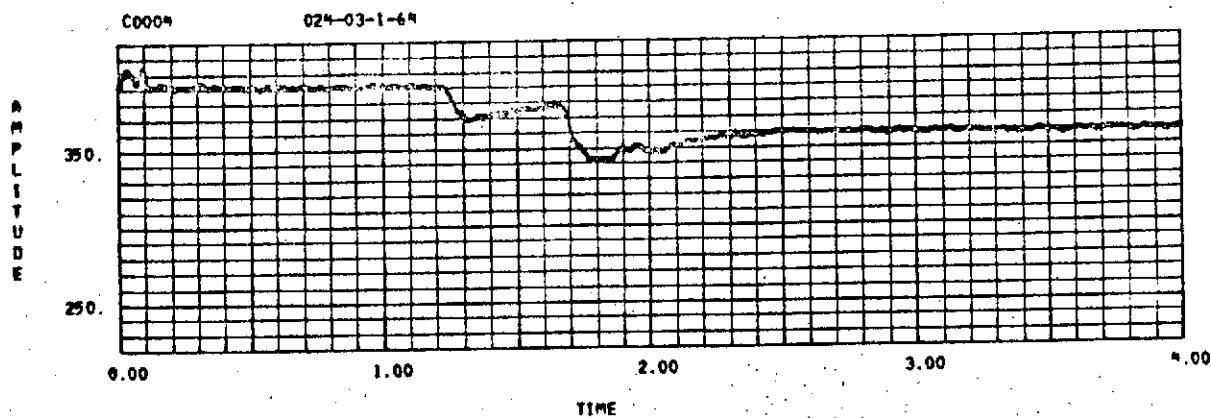
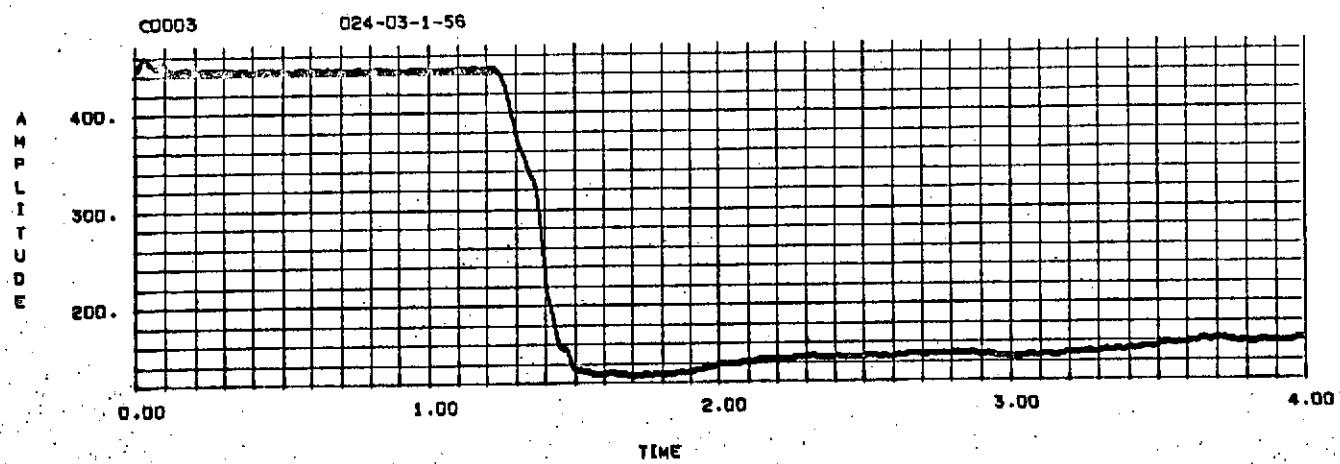
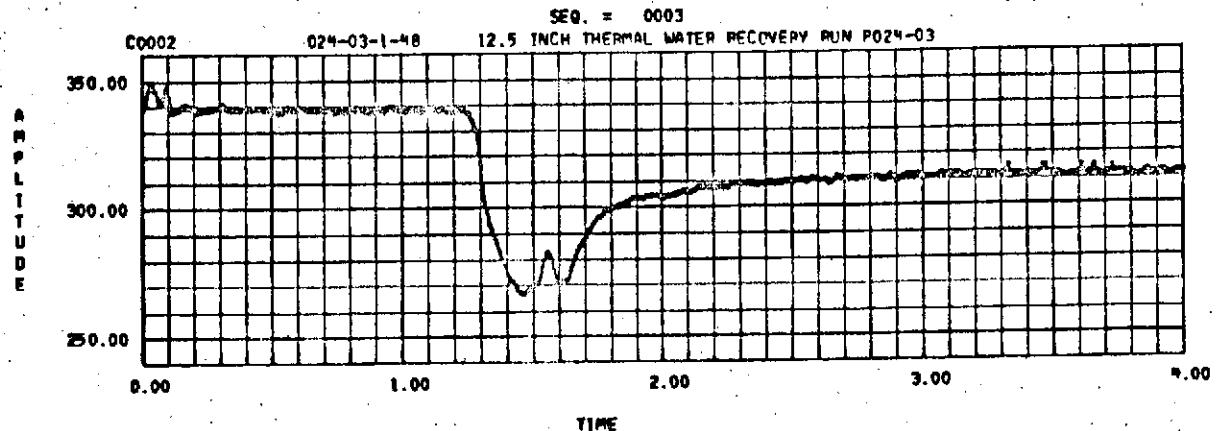
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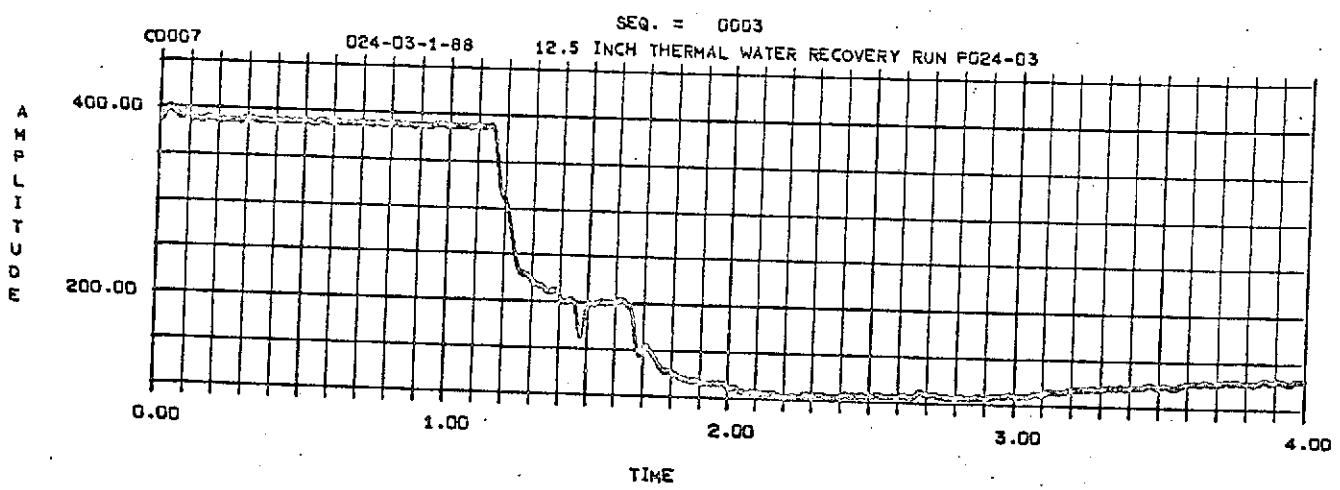
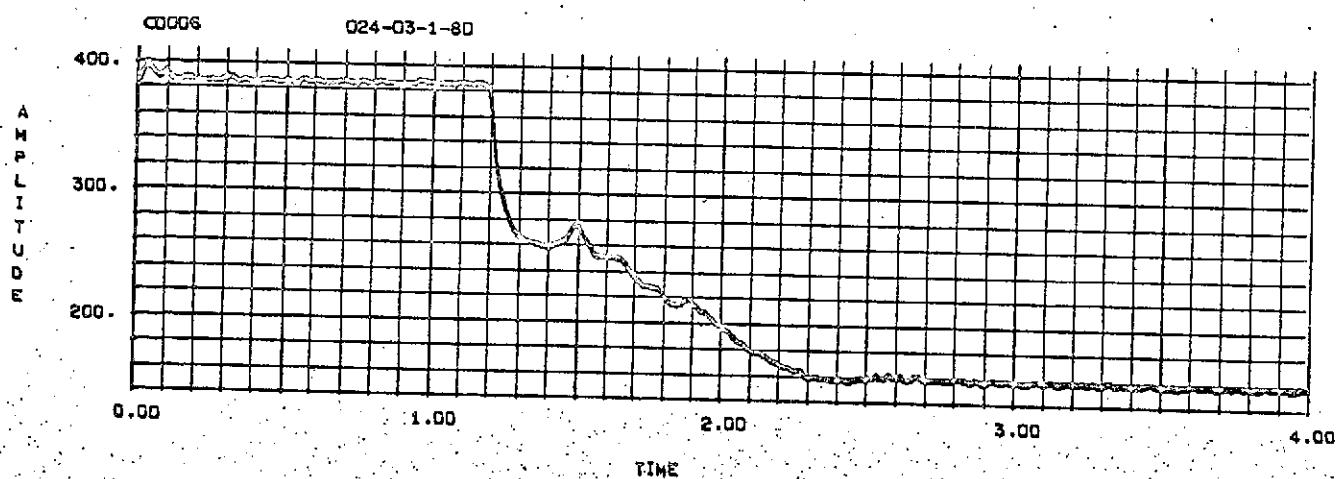
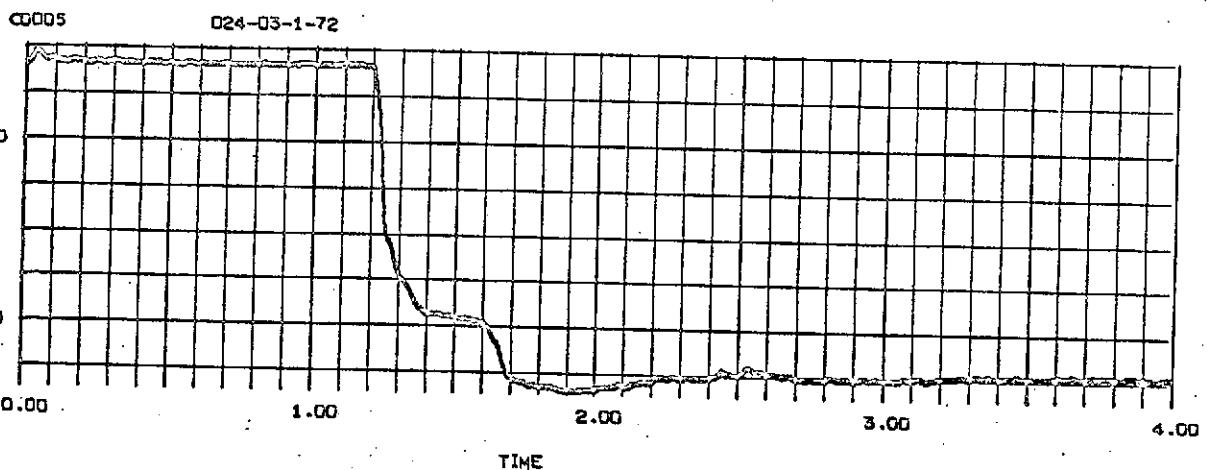
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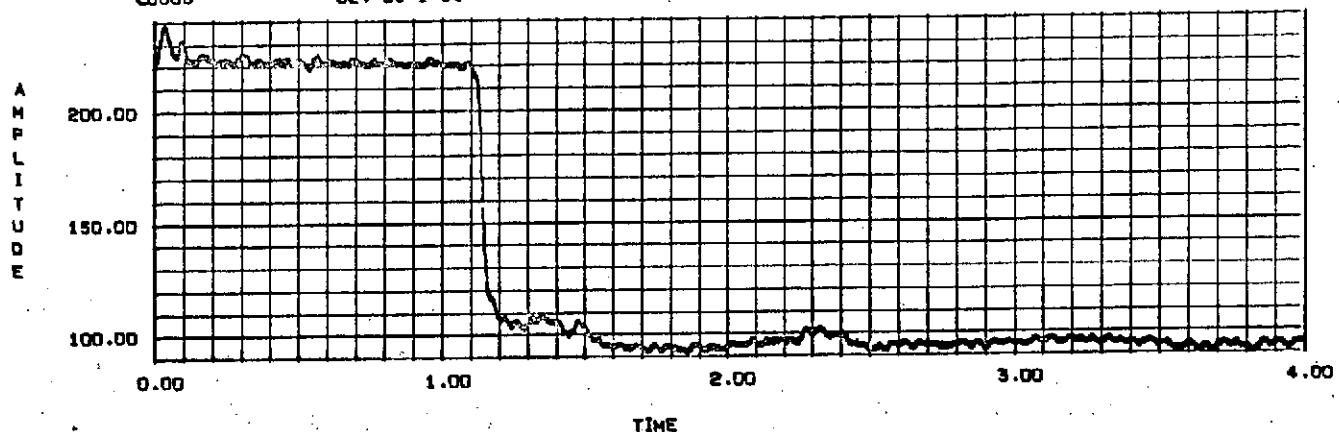




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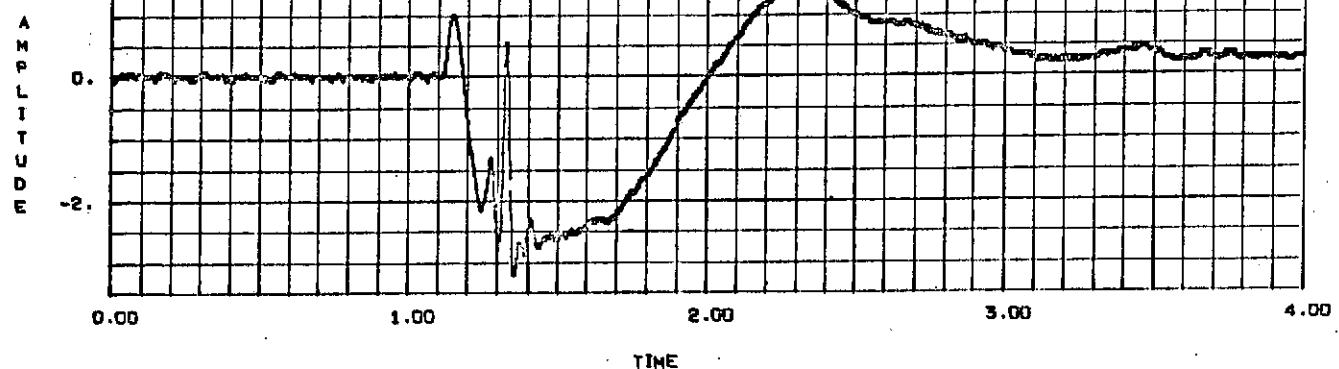
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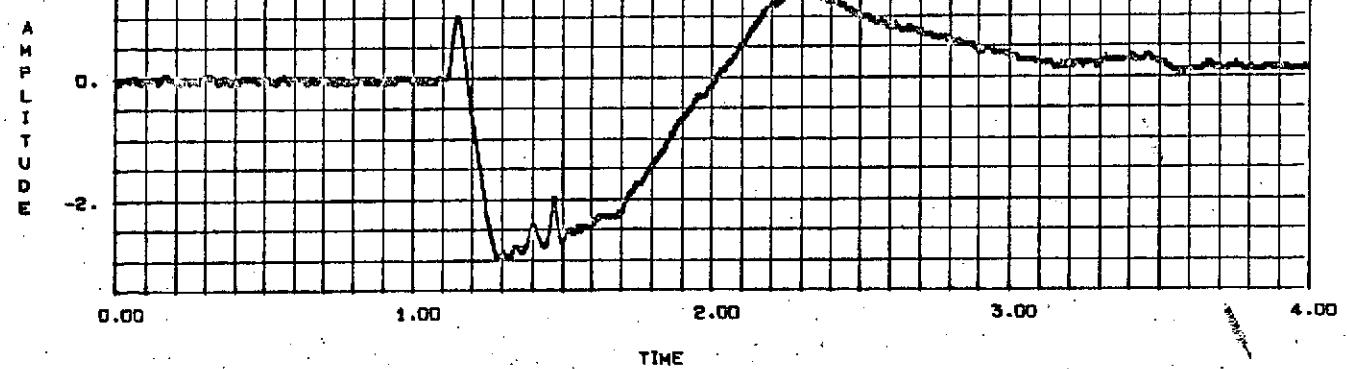
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12.5 INCH THERMAL WATER RECOVERY RUN P024-03

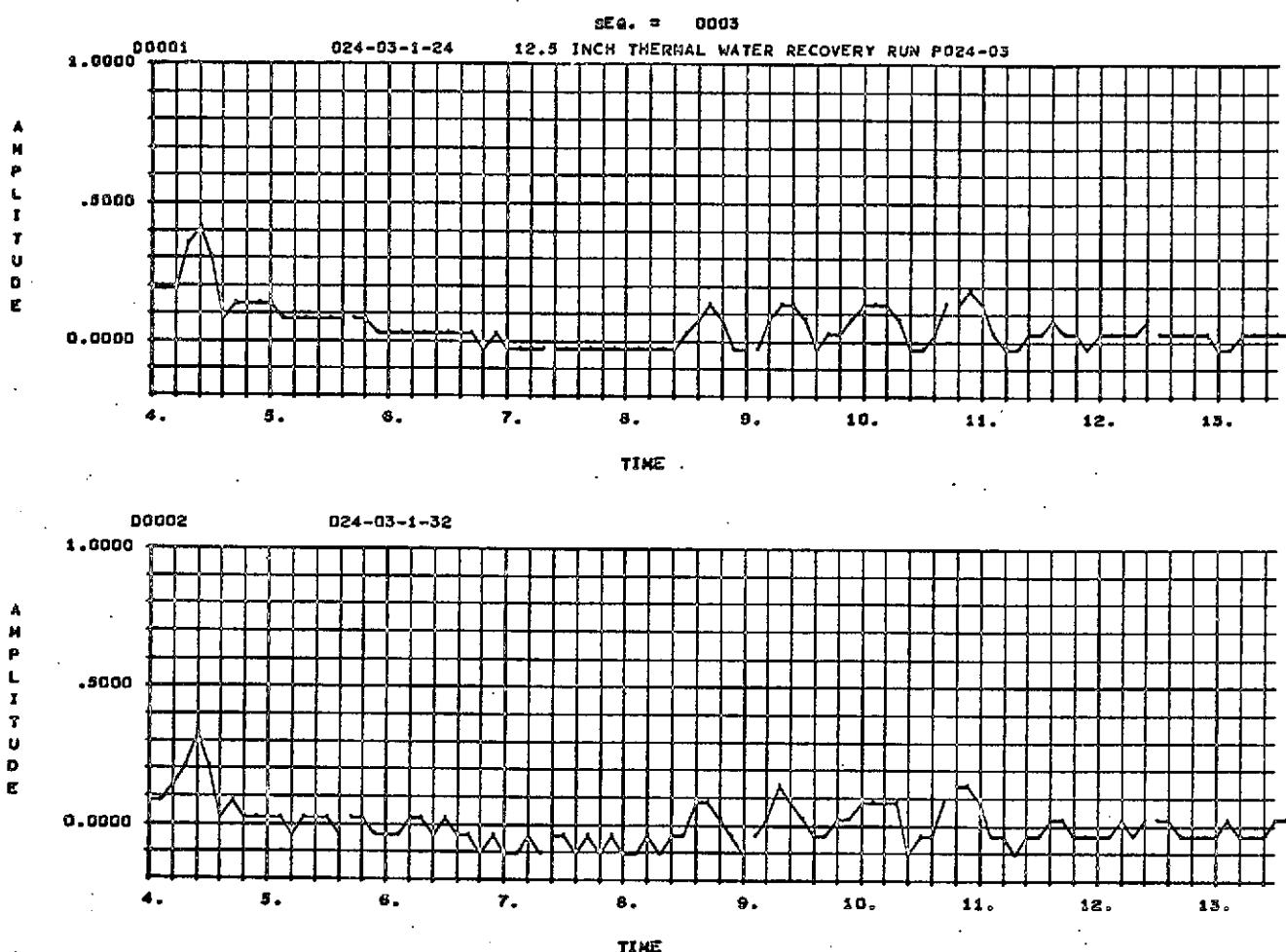


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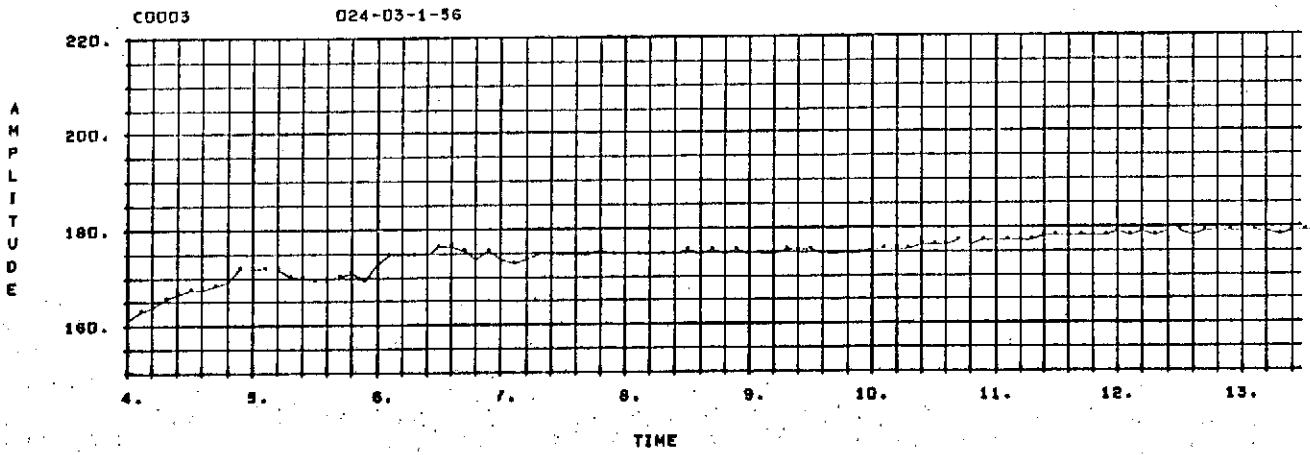
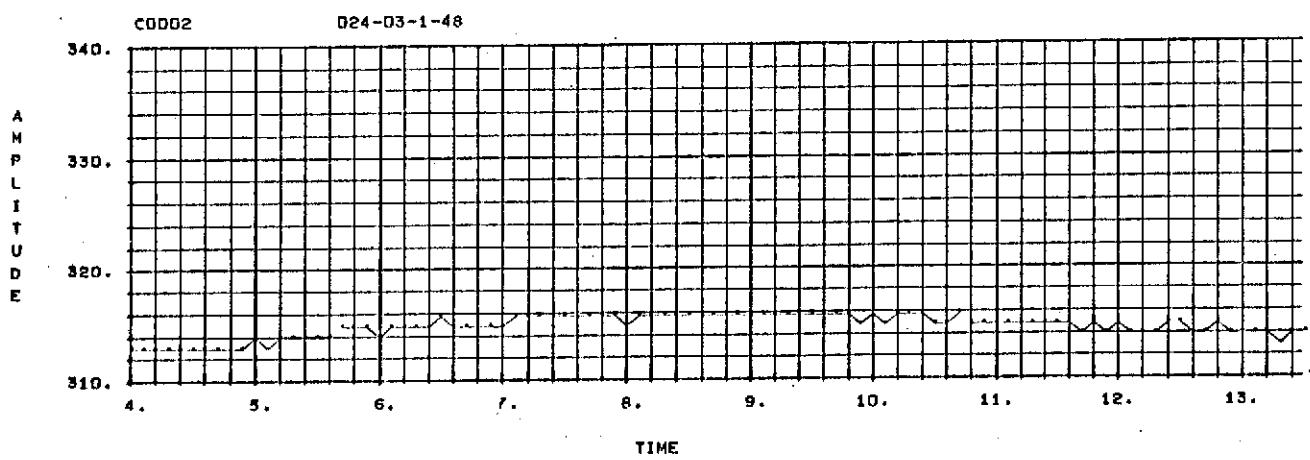
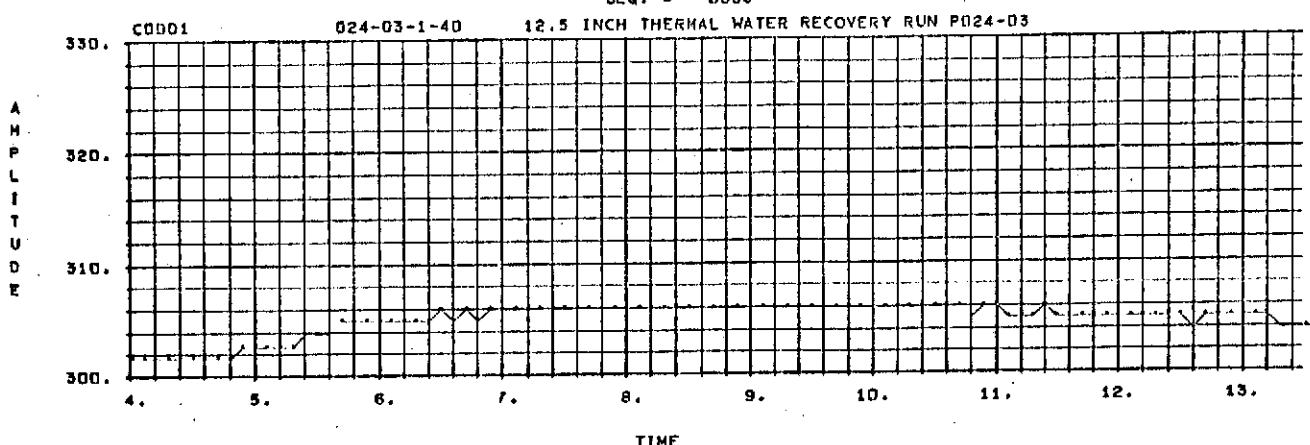
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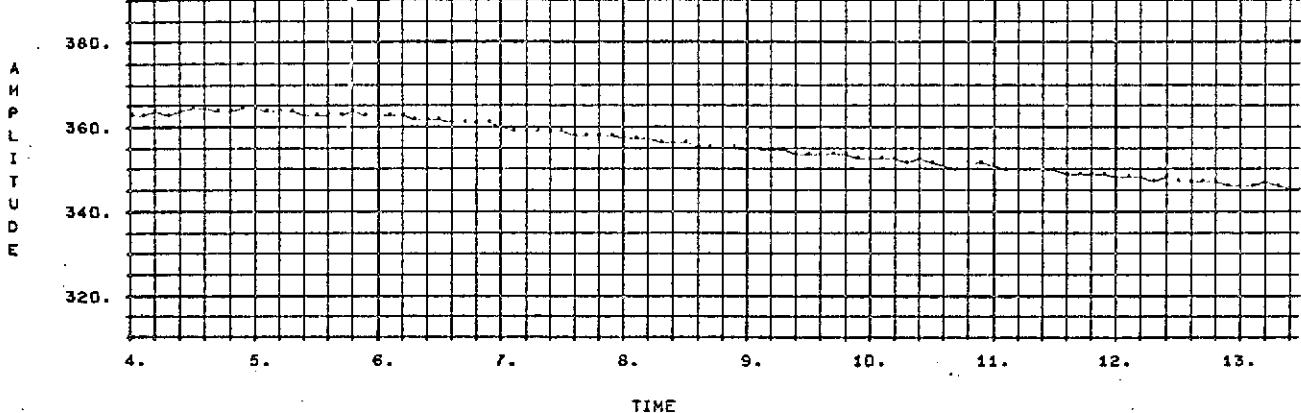
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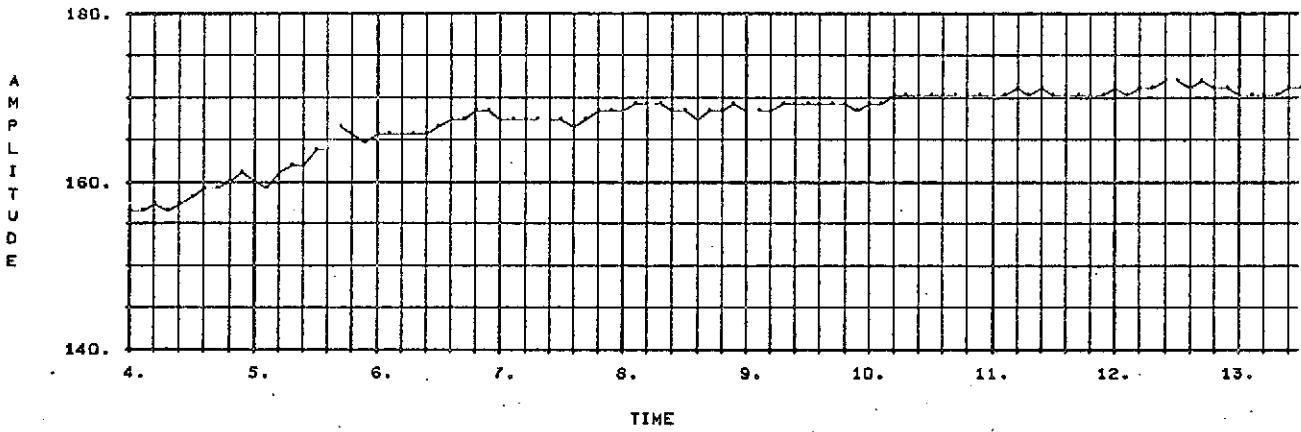
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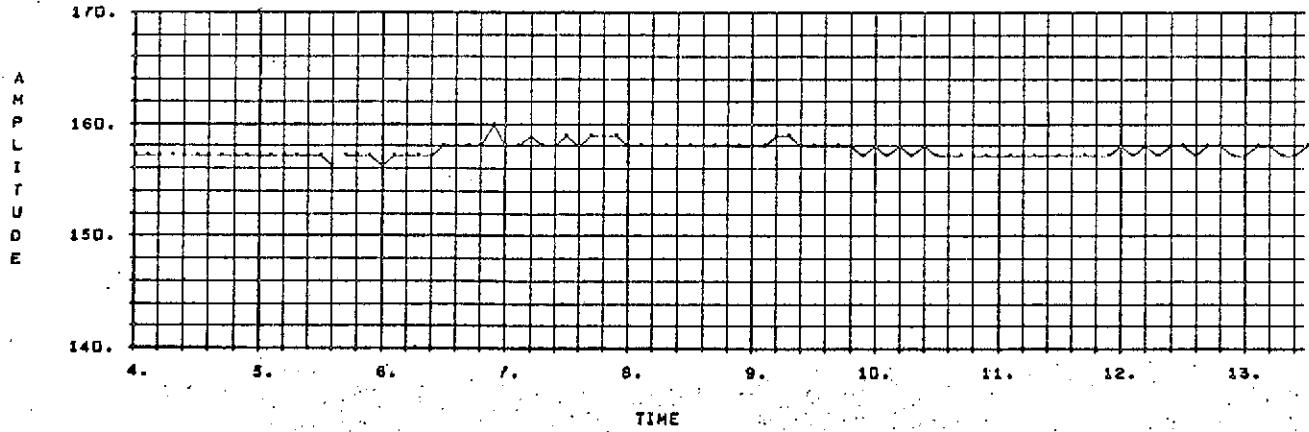
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C0005 024-03-1-72

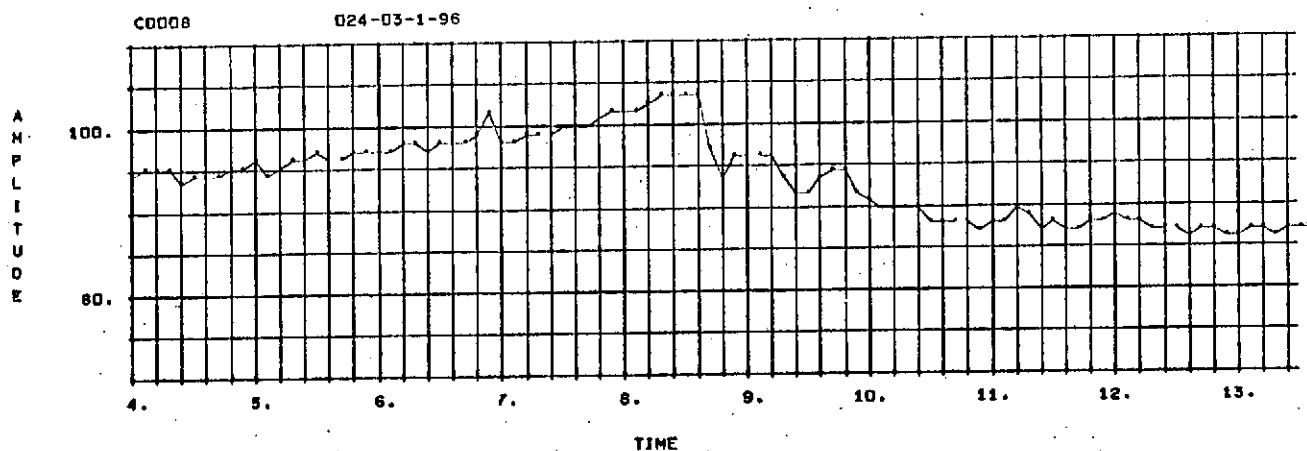
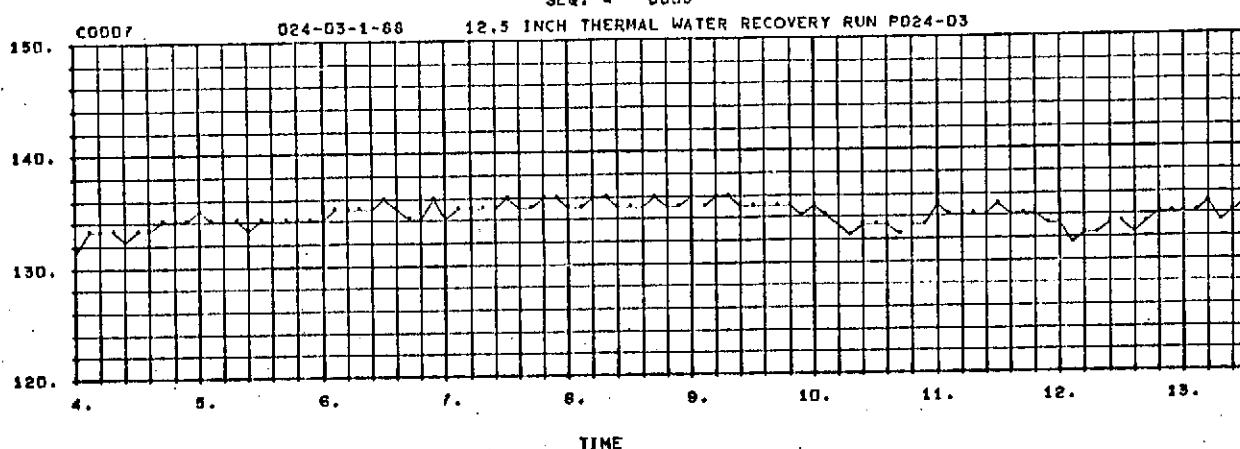


C0006 024-03-1-80



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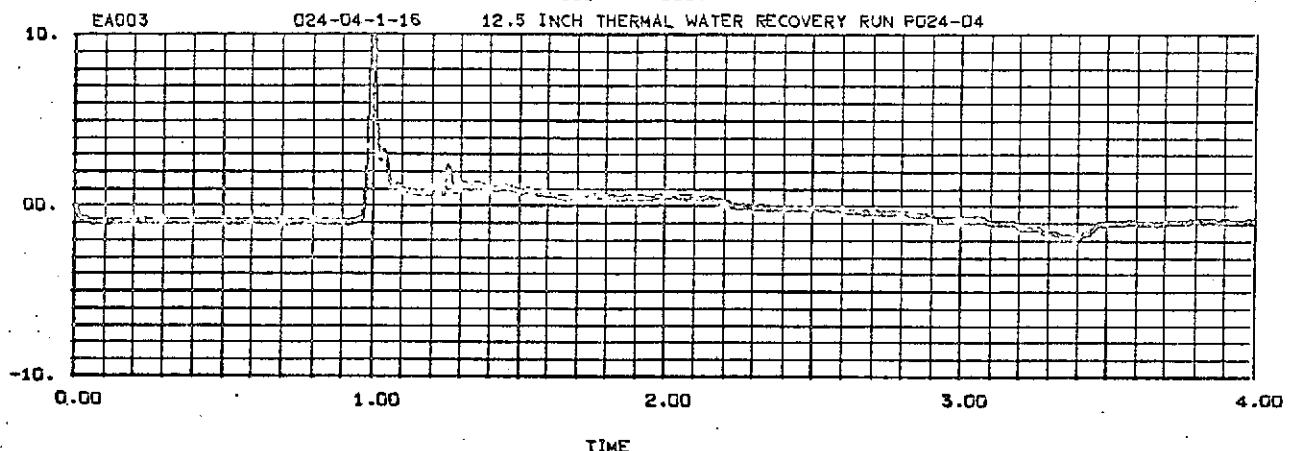
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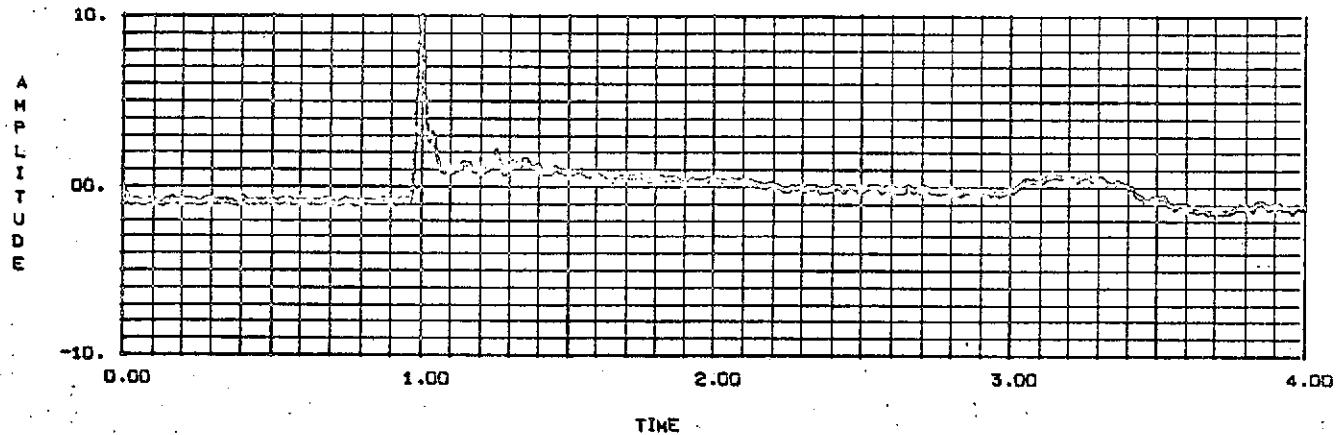
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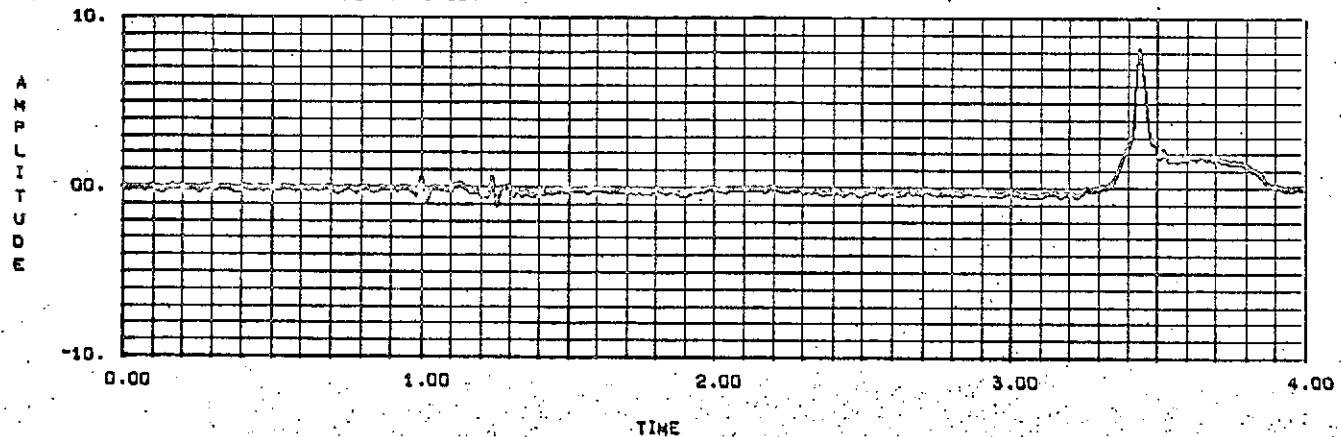
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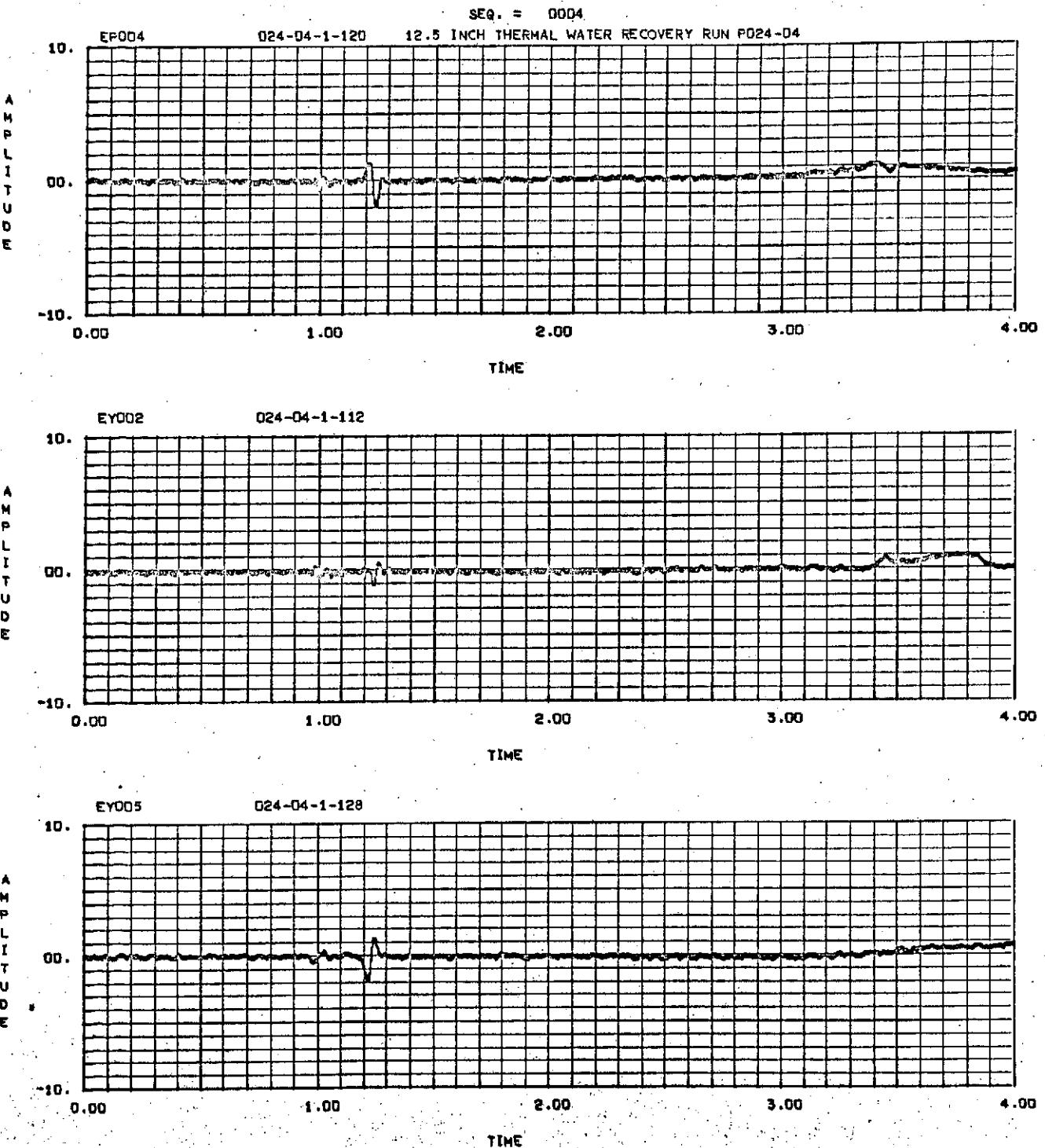


EA006 024-04-1-136



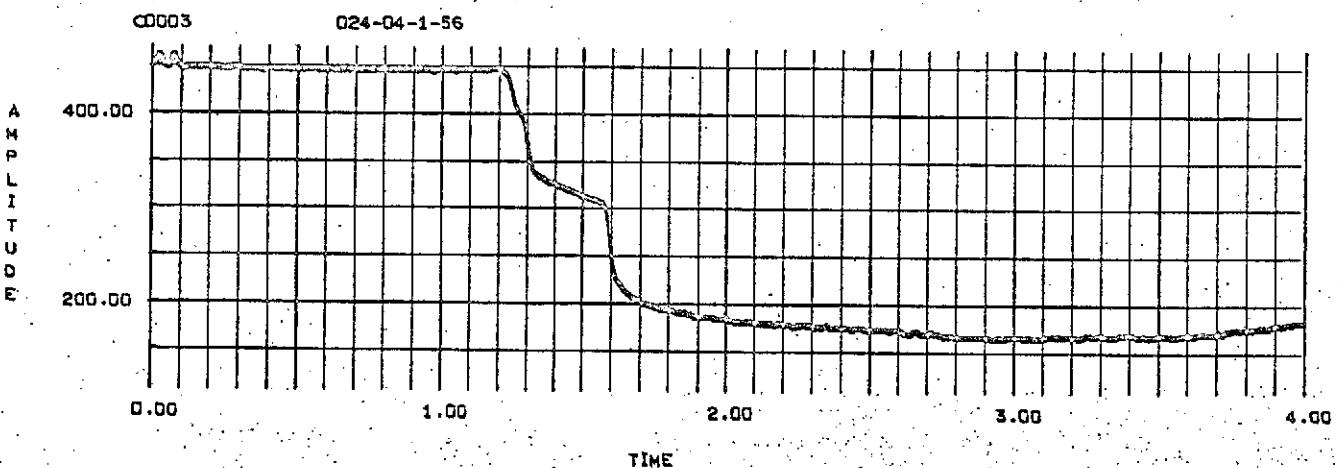
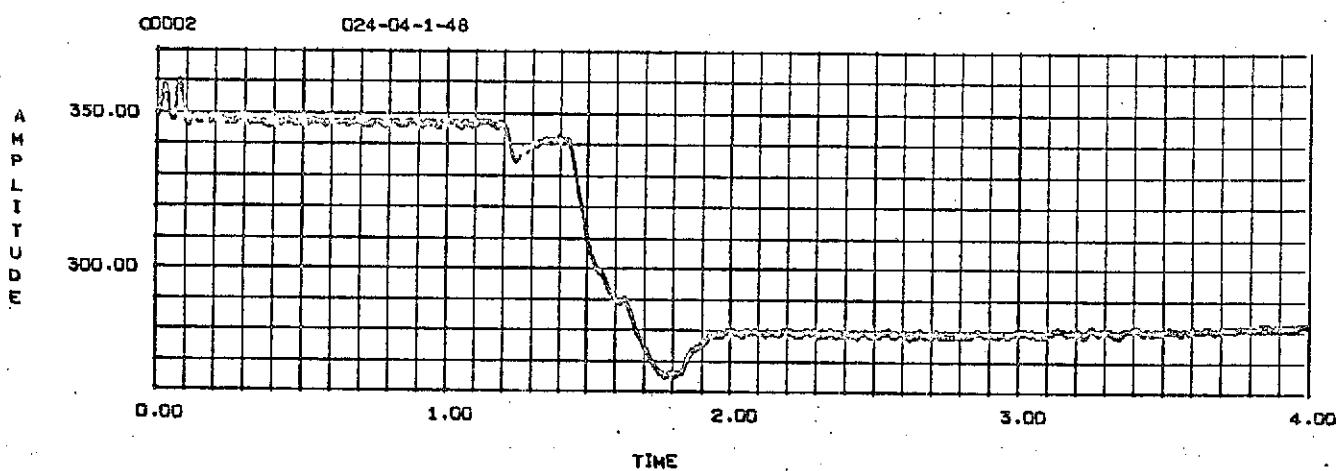
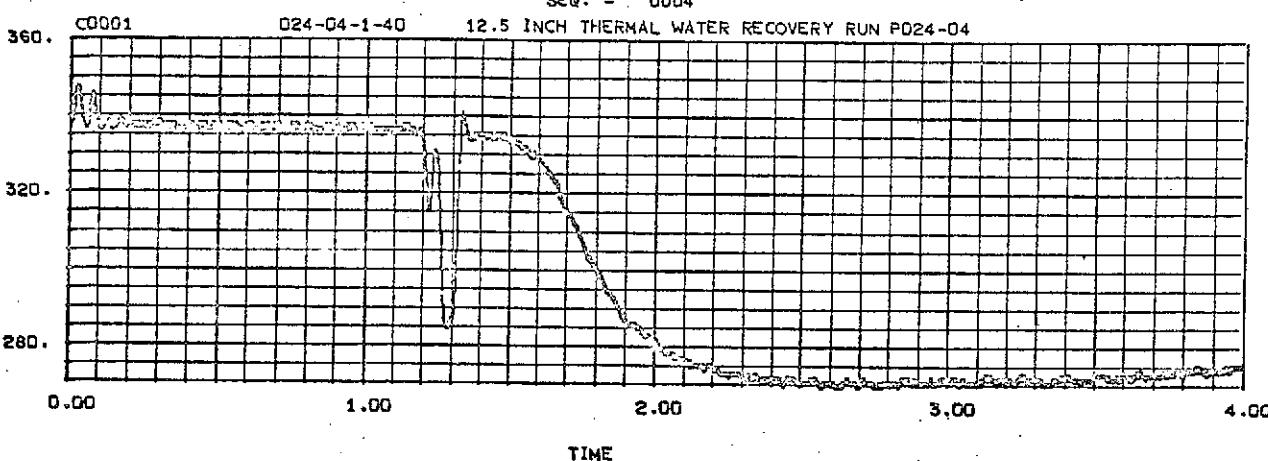
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SEQ. = 0004

C0004

024-04-1-64

12.5 INCH THERMAL WATER RECOVERY RUN P024-04

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400.00
350.00
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1.00

2.00

3.00

4.00

TIME

C0005

024-04-1-72

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D
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300.
200.

0.00

1.00

2.00

3.00

4.00

TIME

C0006

024-04-1-80

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D
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350.00
300.00
250.00
200.00

0.00

1.00

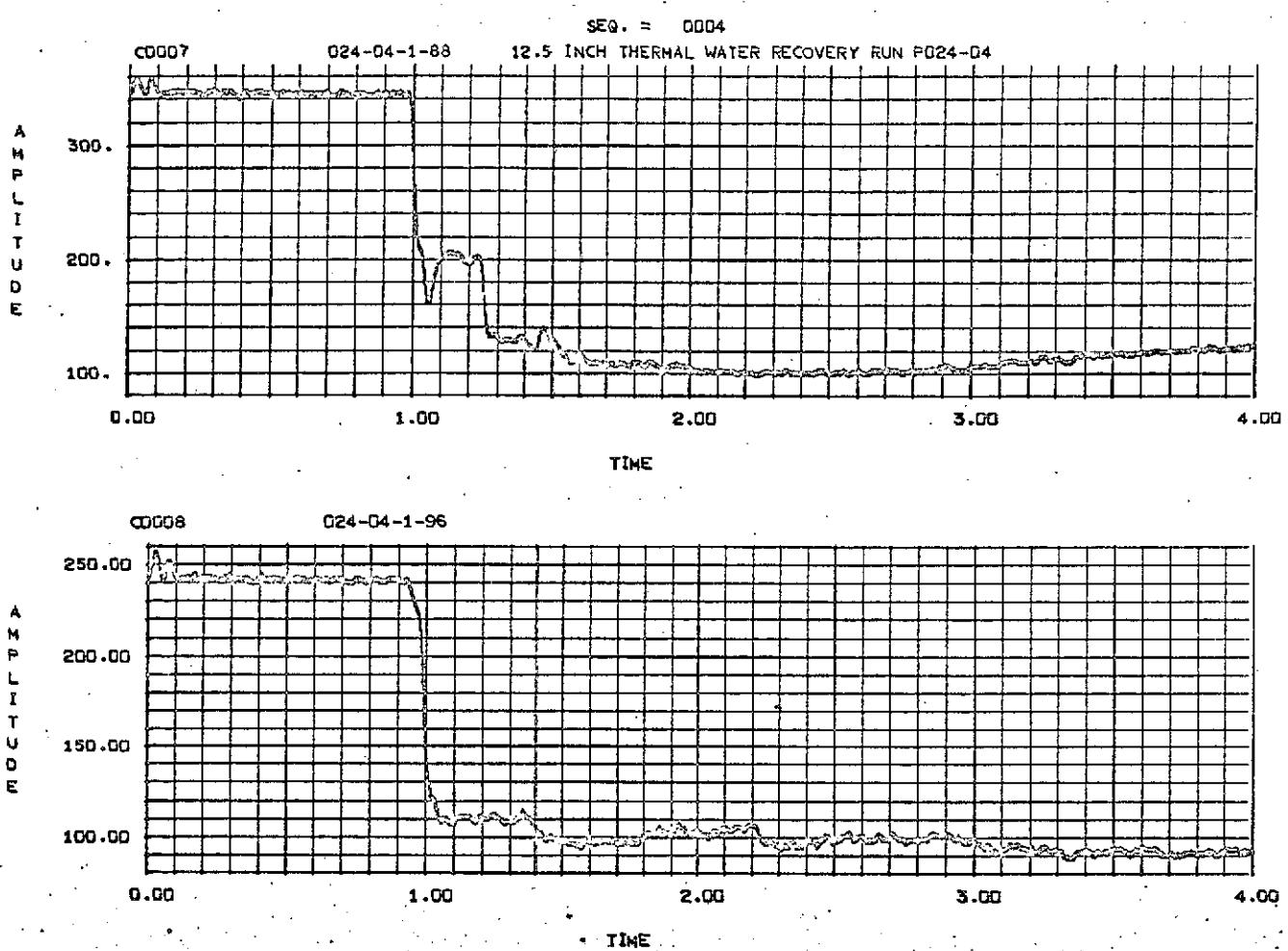
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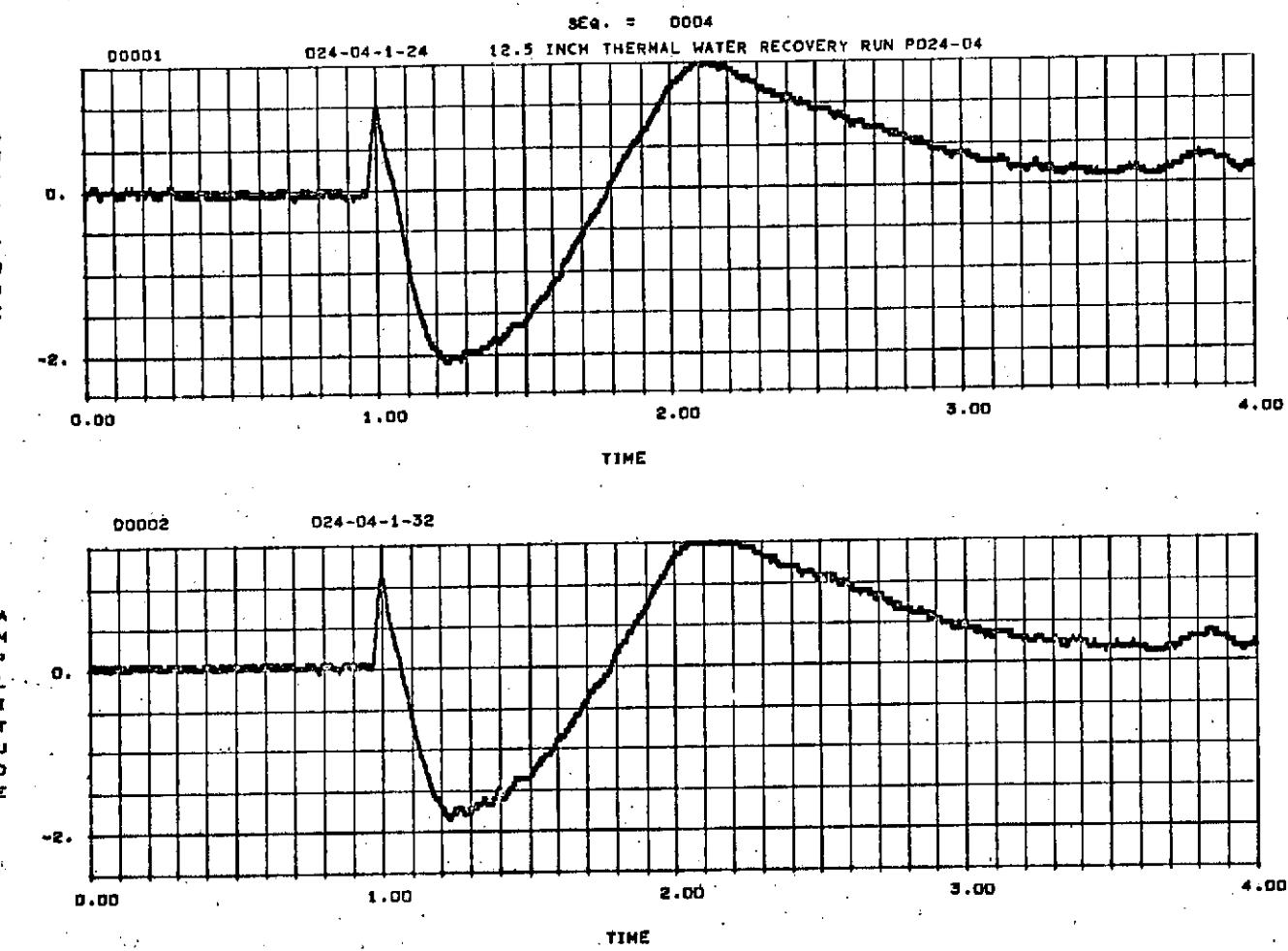
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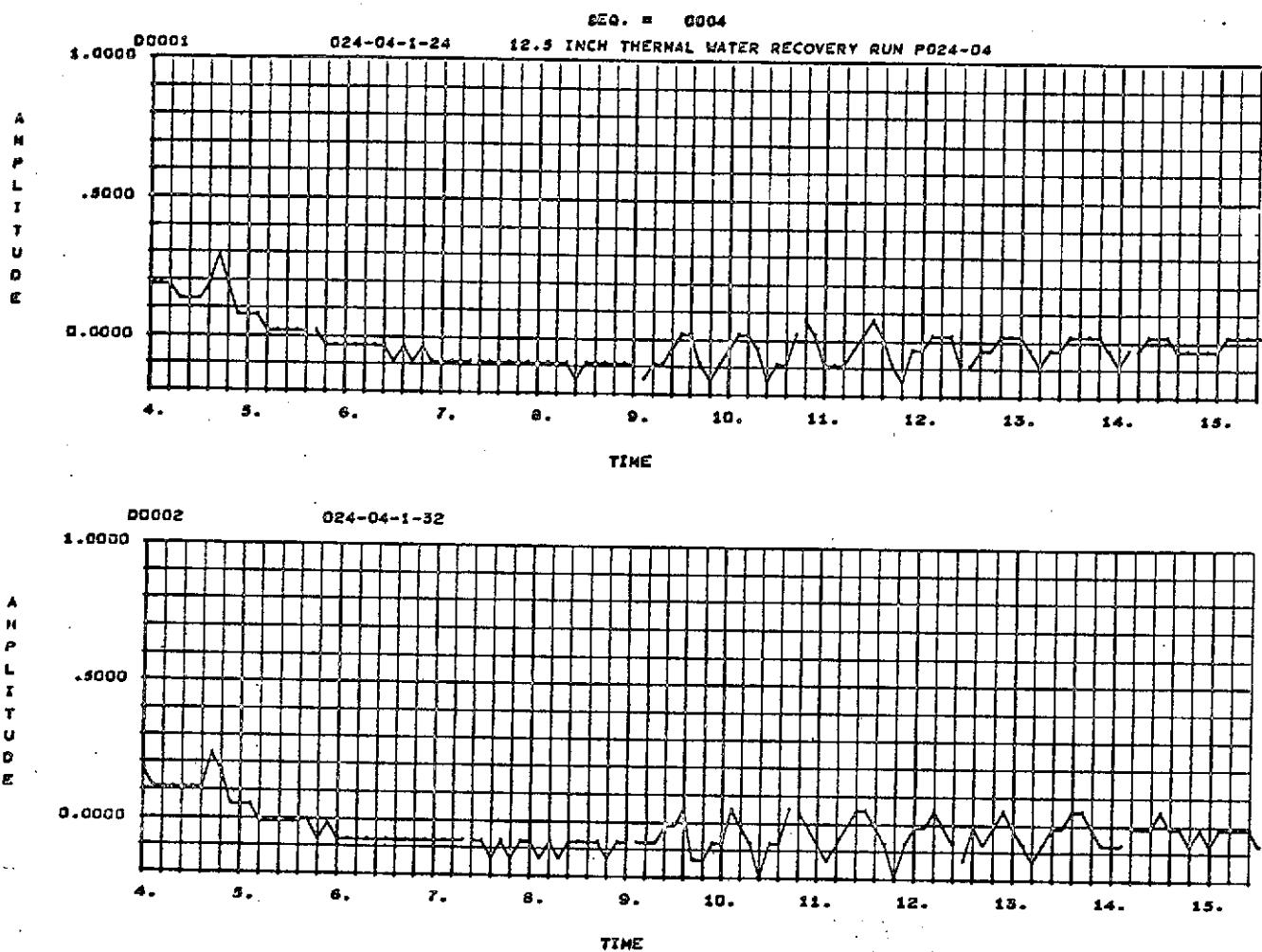
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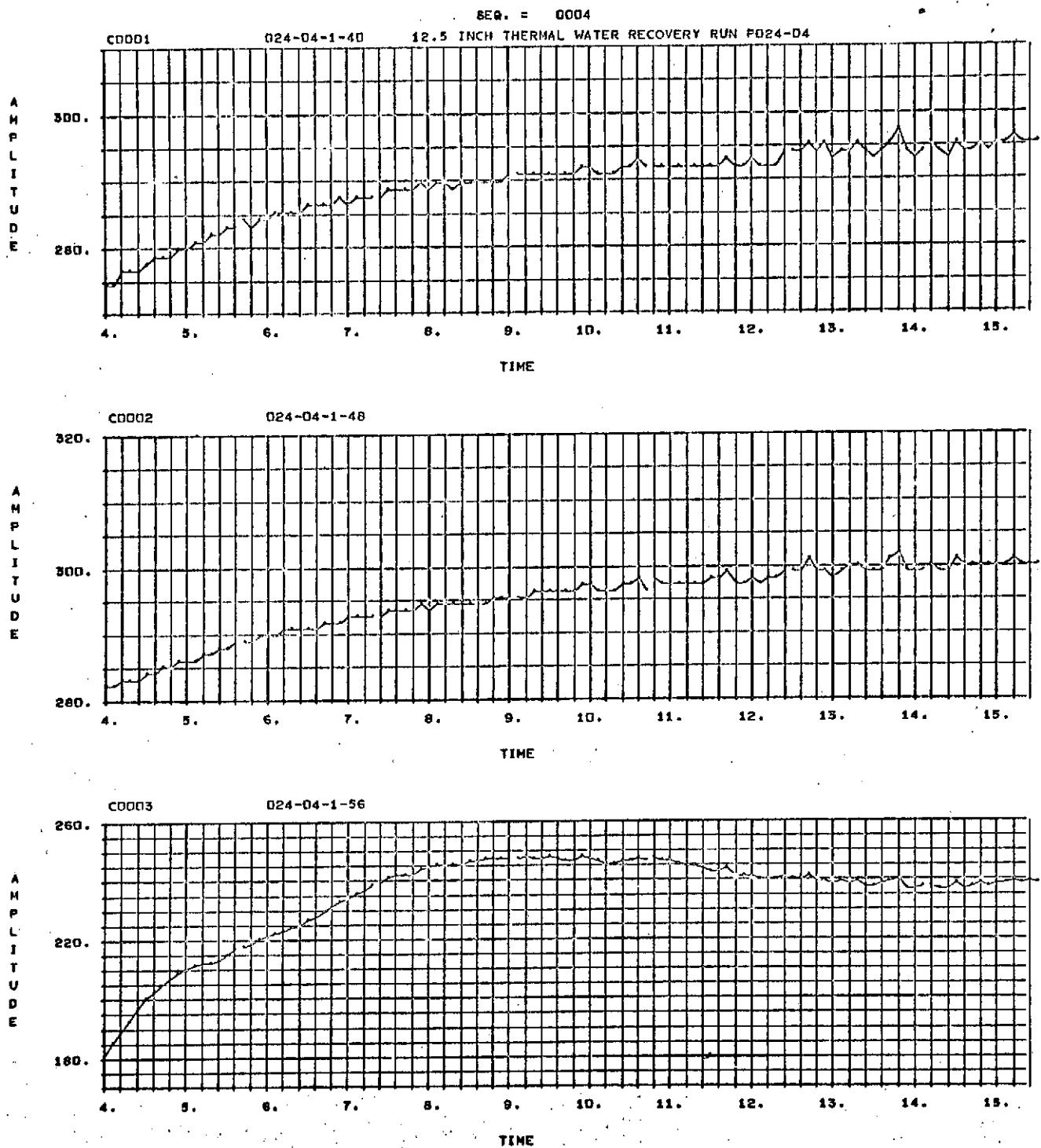
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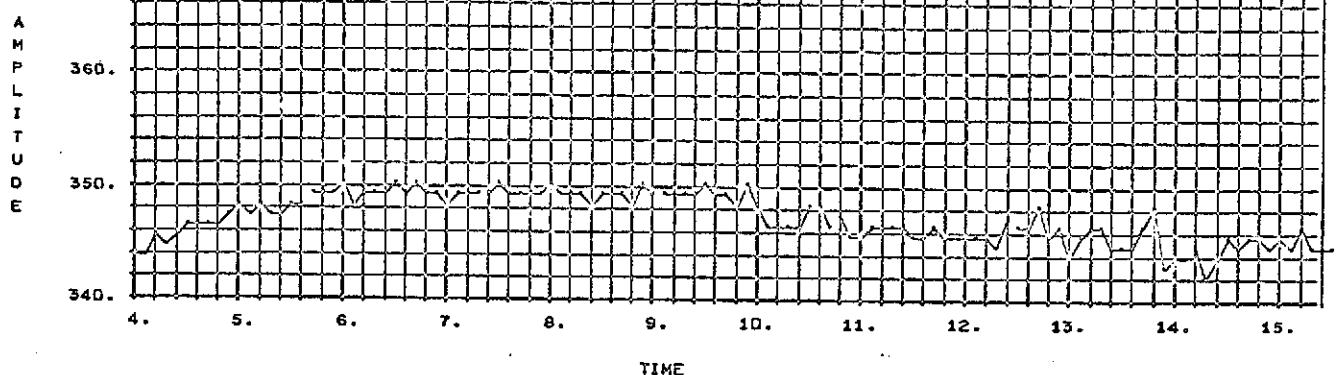




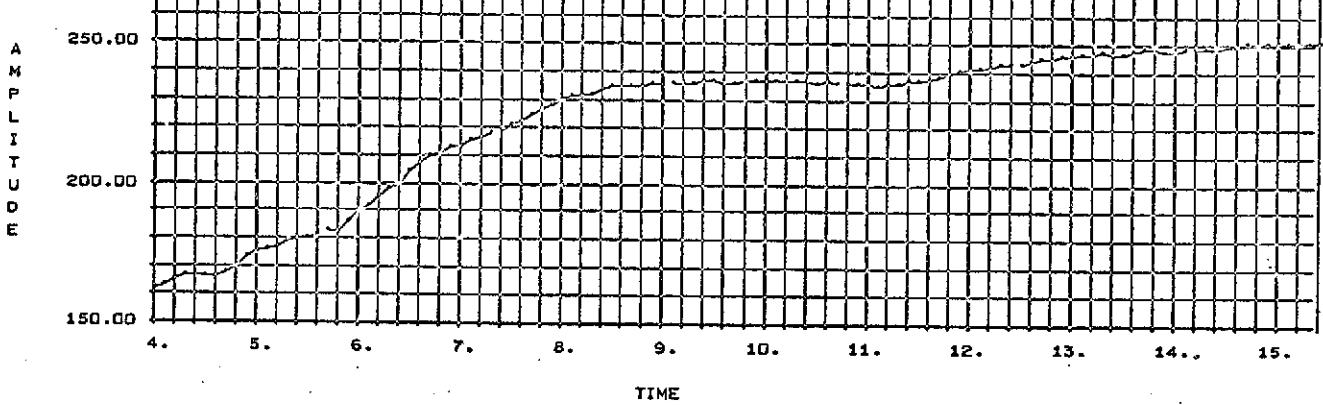
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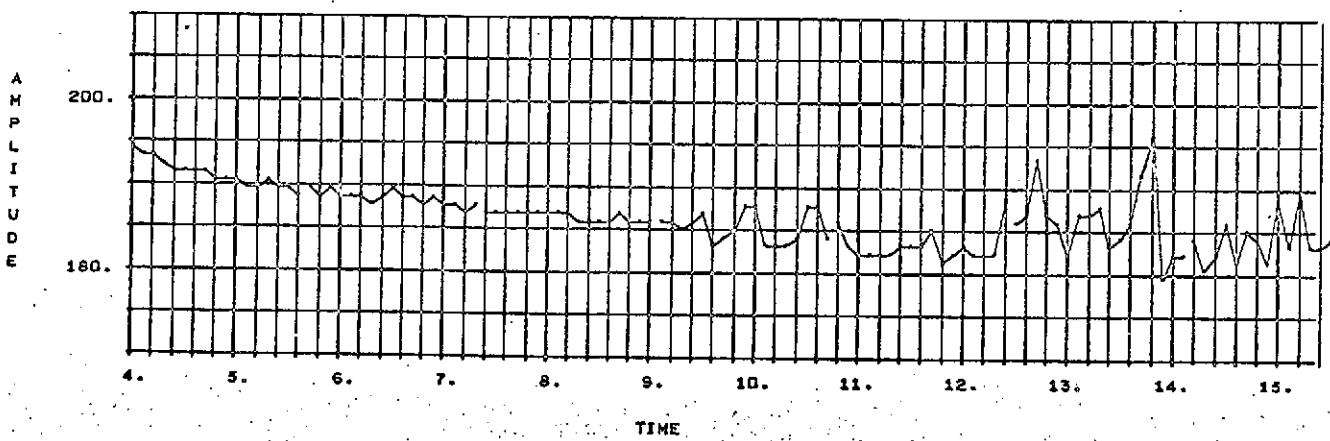
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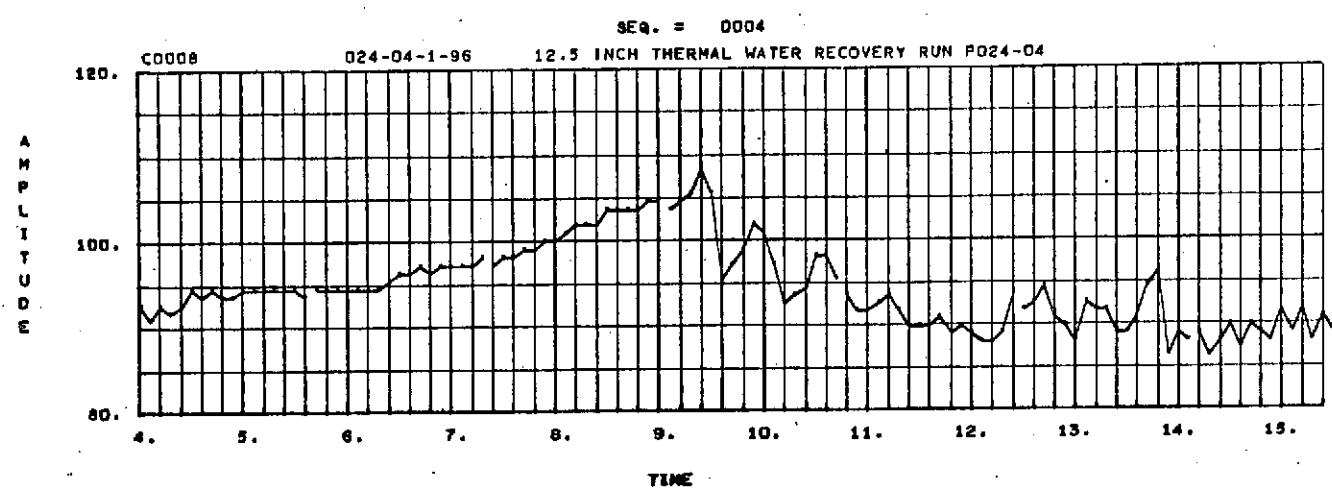
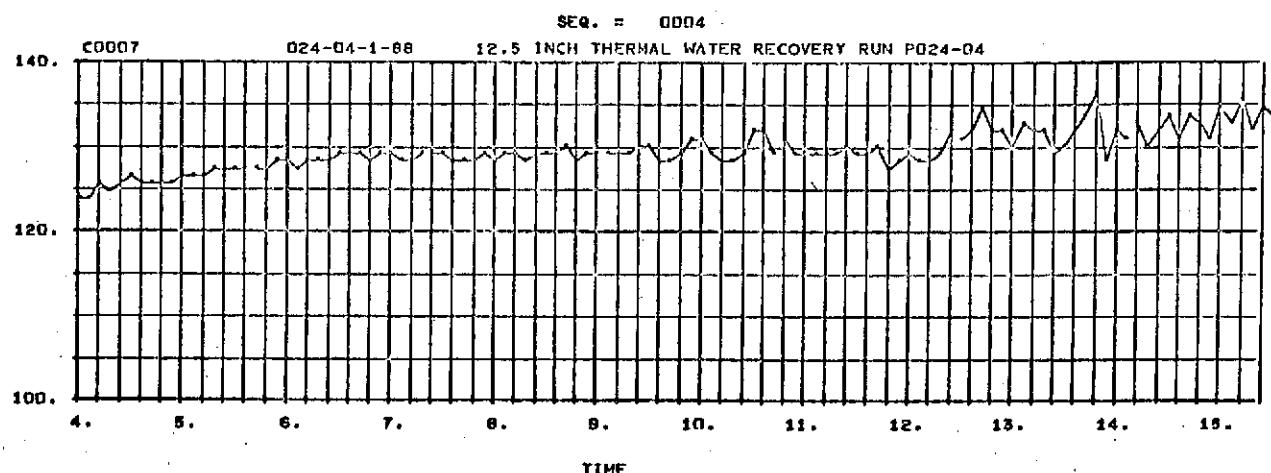


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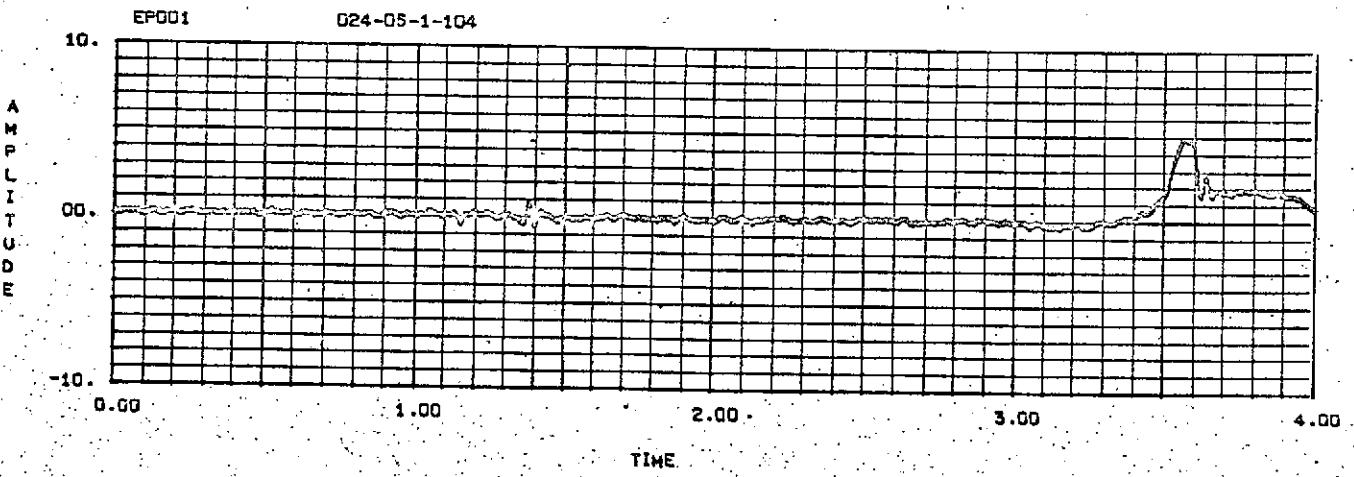
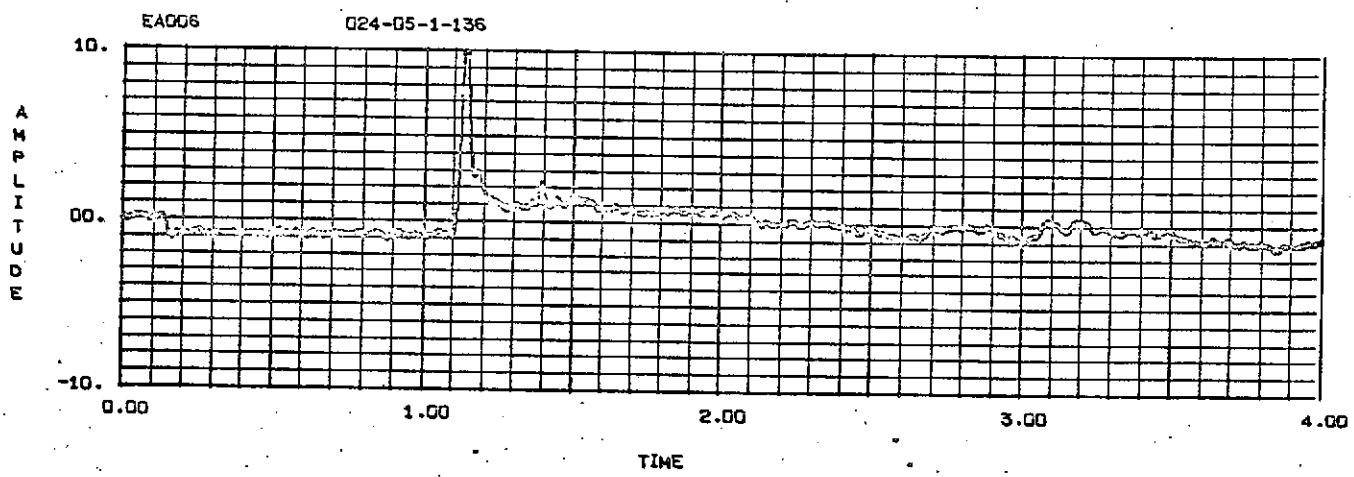
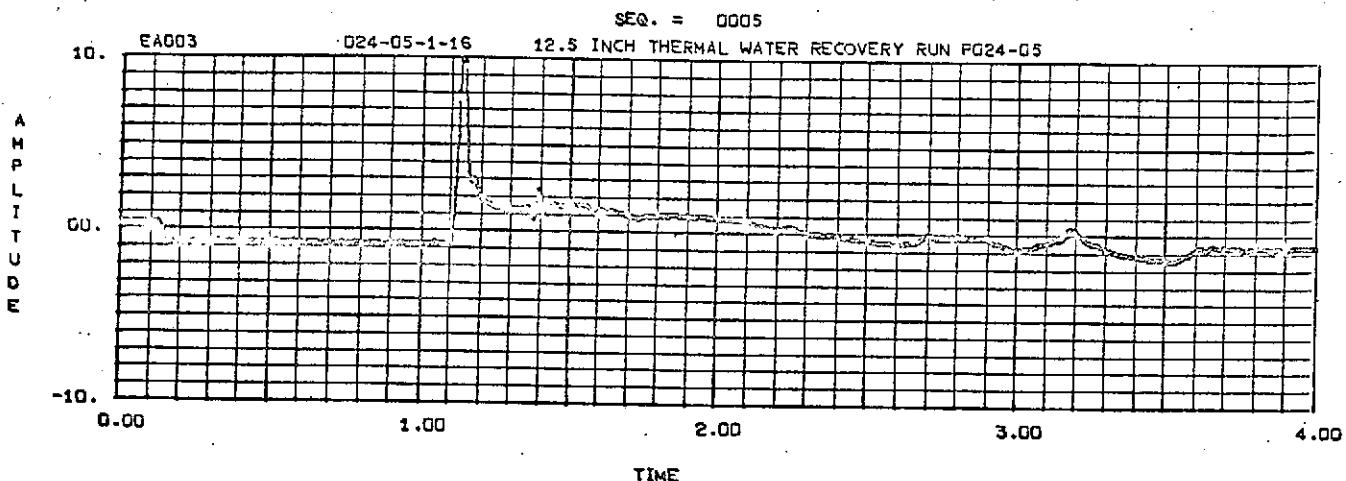


C0006 024-04-1-80





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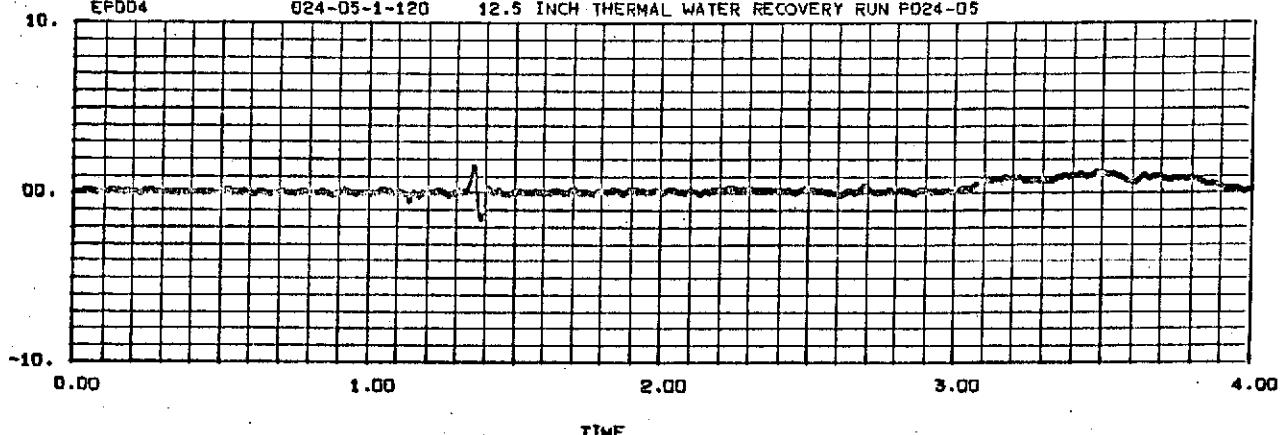
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024-05-1-120

12.5 INCH THERMAL WATER RECOVERY RUN P024-05

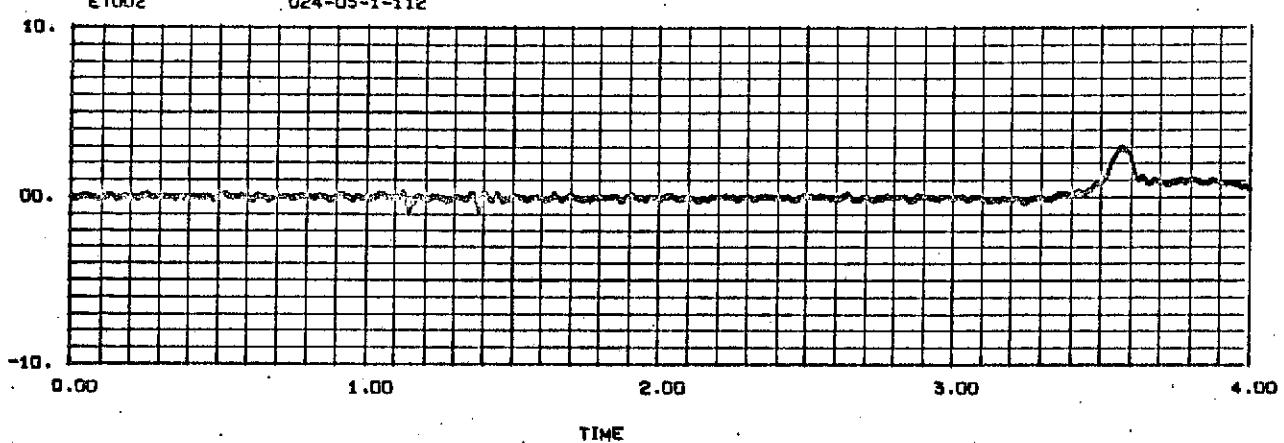
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024-05-1-112

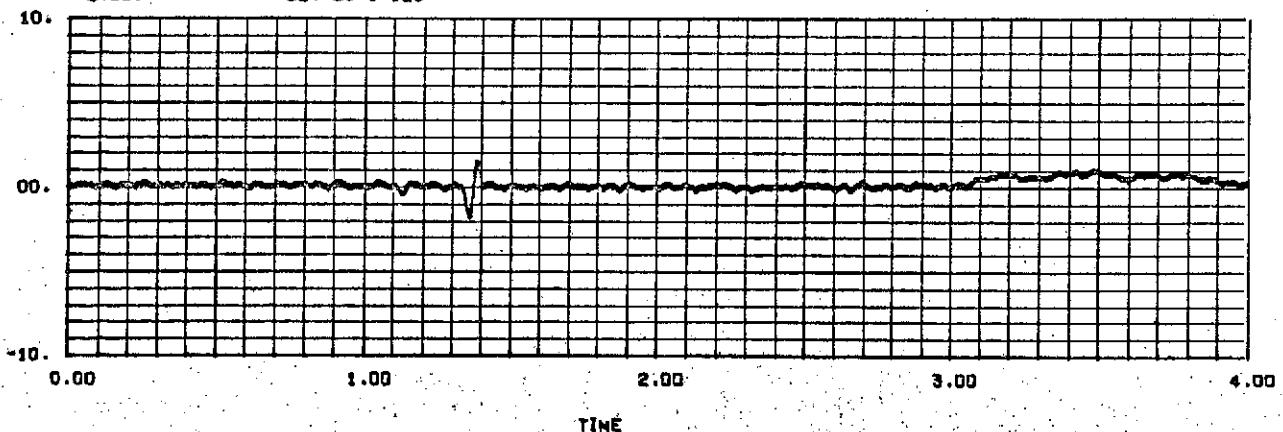
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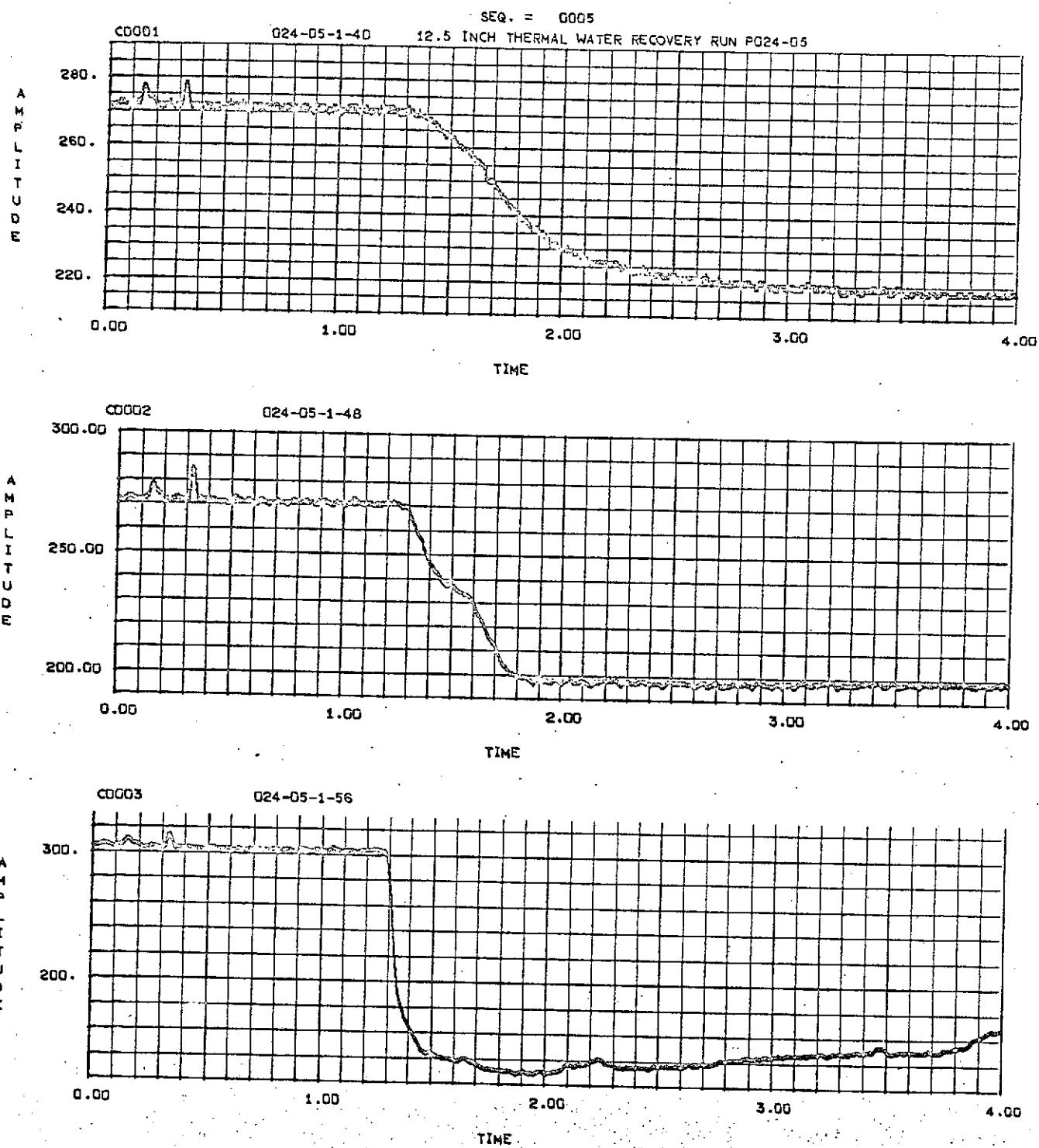
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024-05-1-128

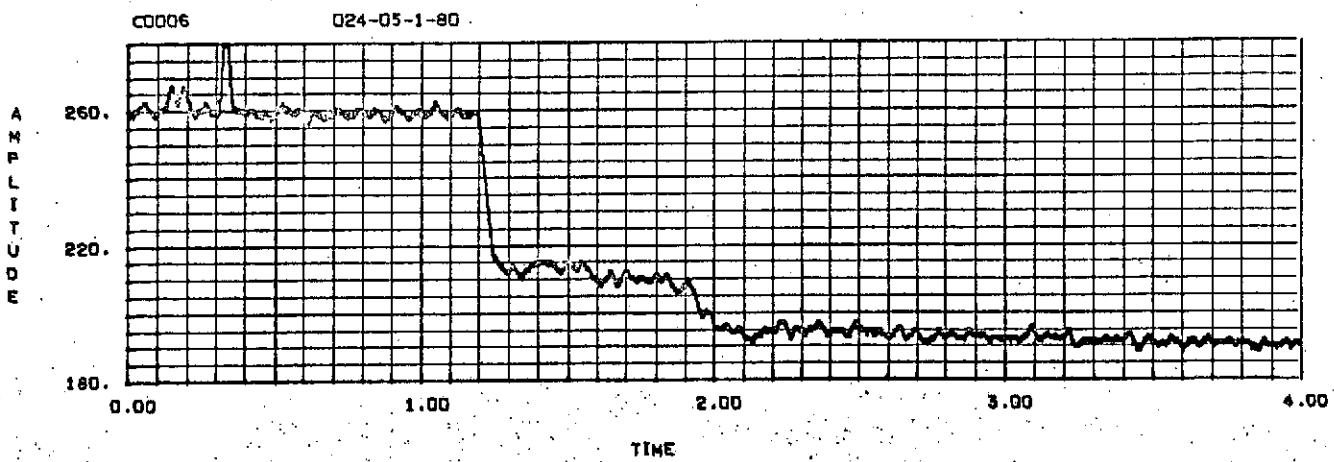
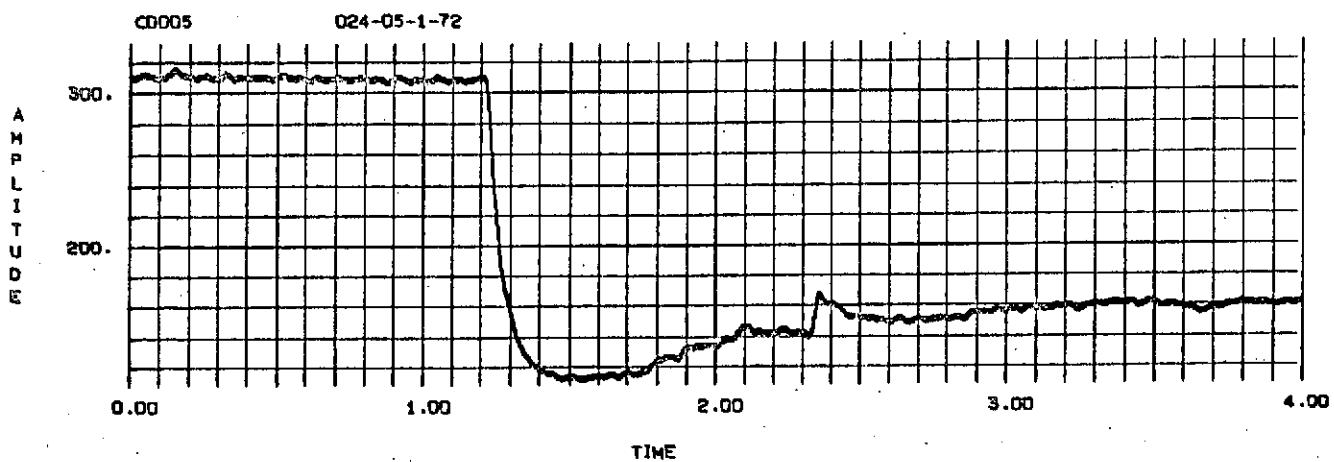
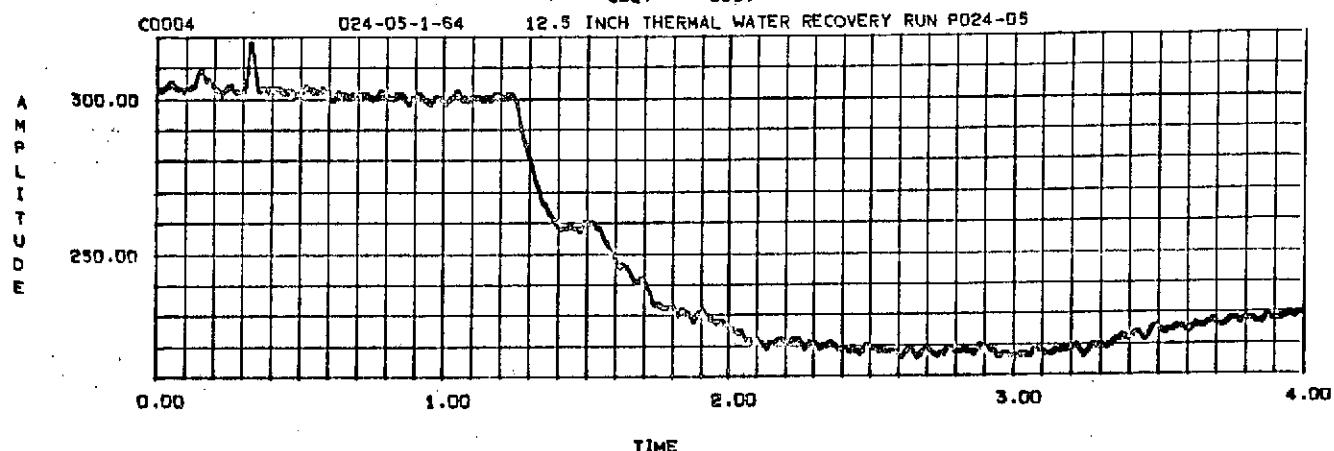
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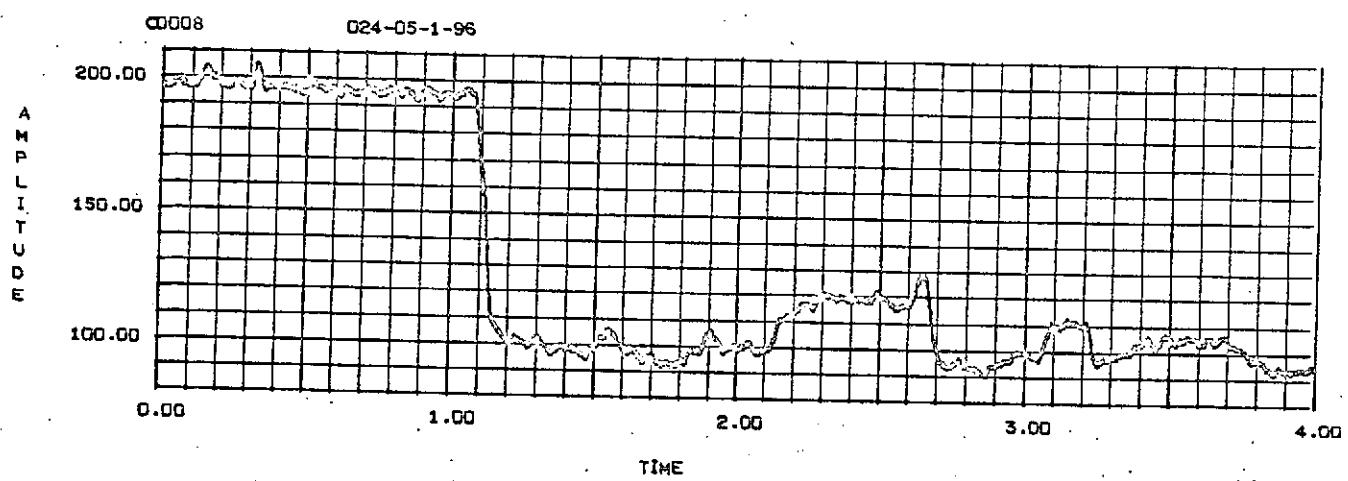
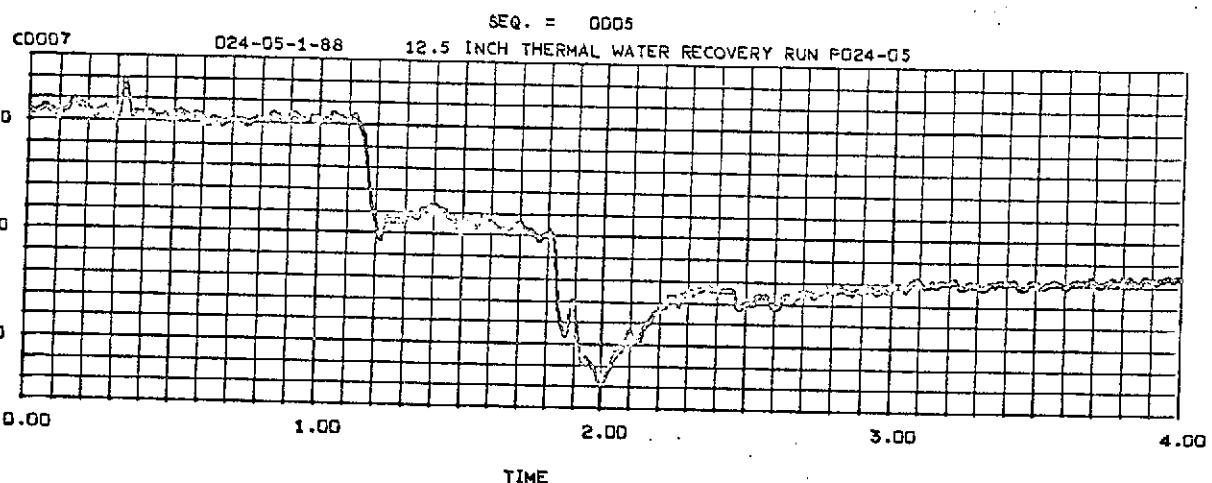
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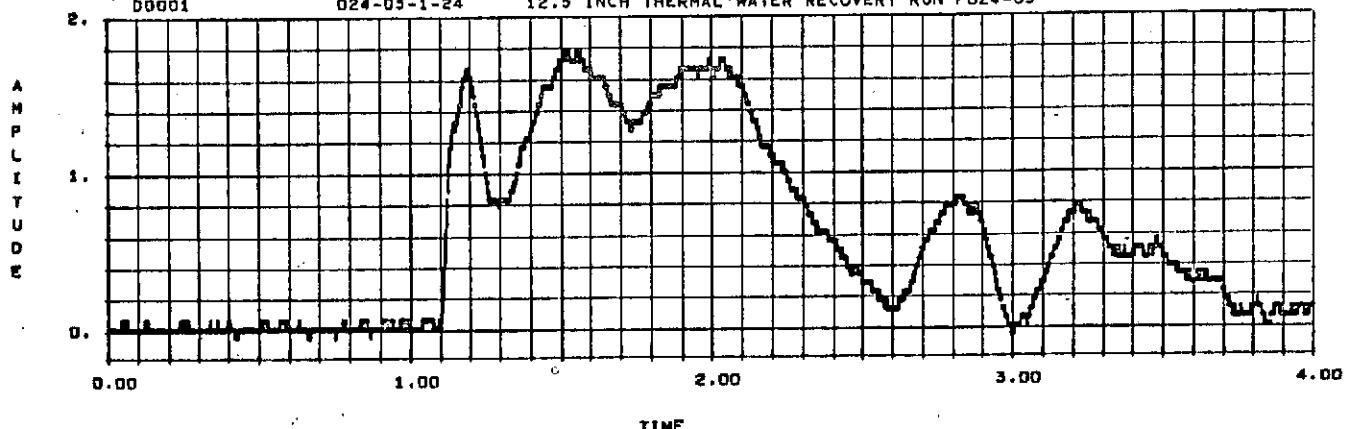


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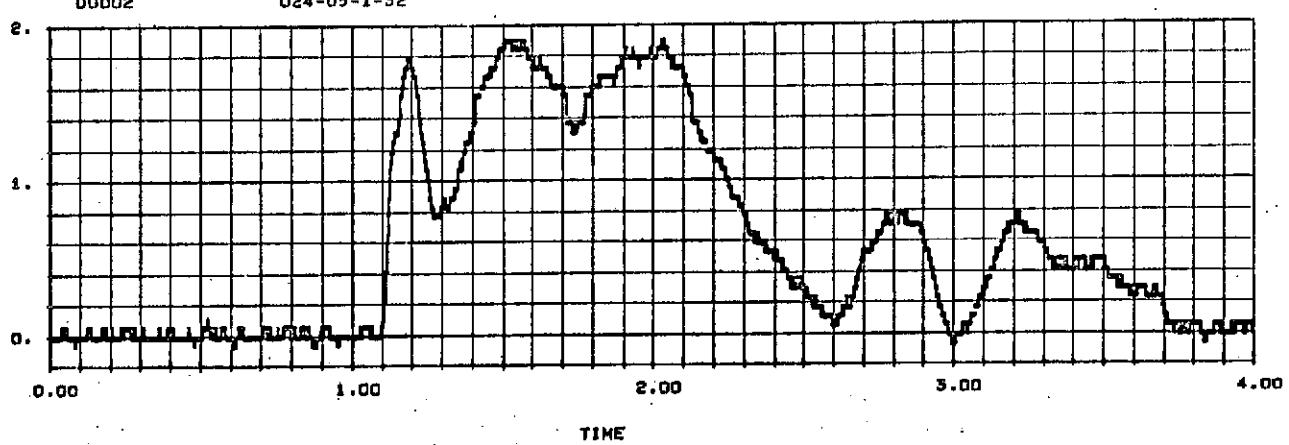
12.5 INCH THERMAL WATER RECOVERY RUN P024-05



AMPLITUDE

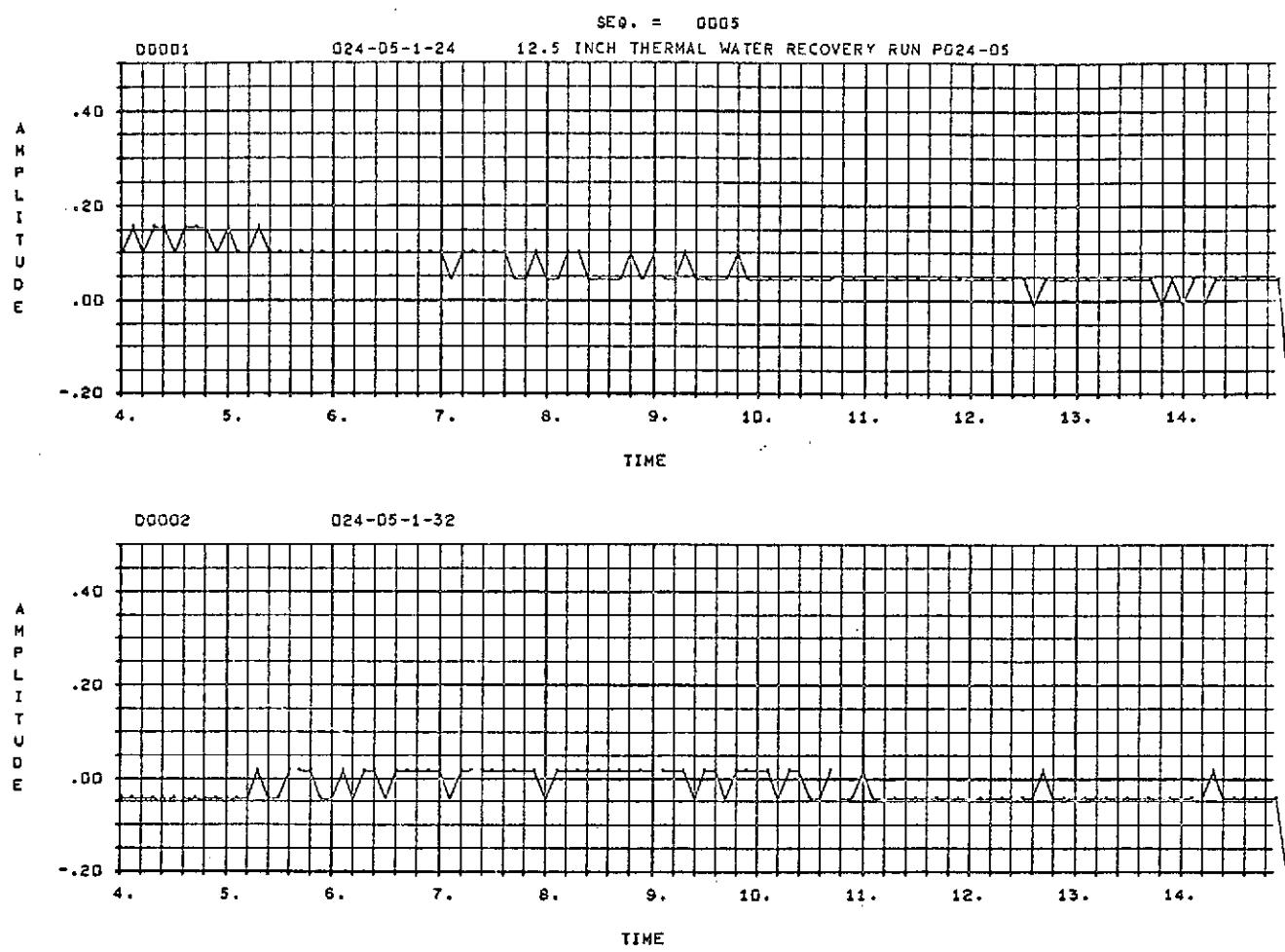
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024-05-1-32



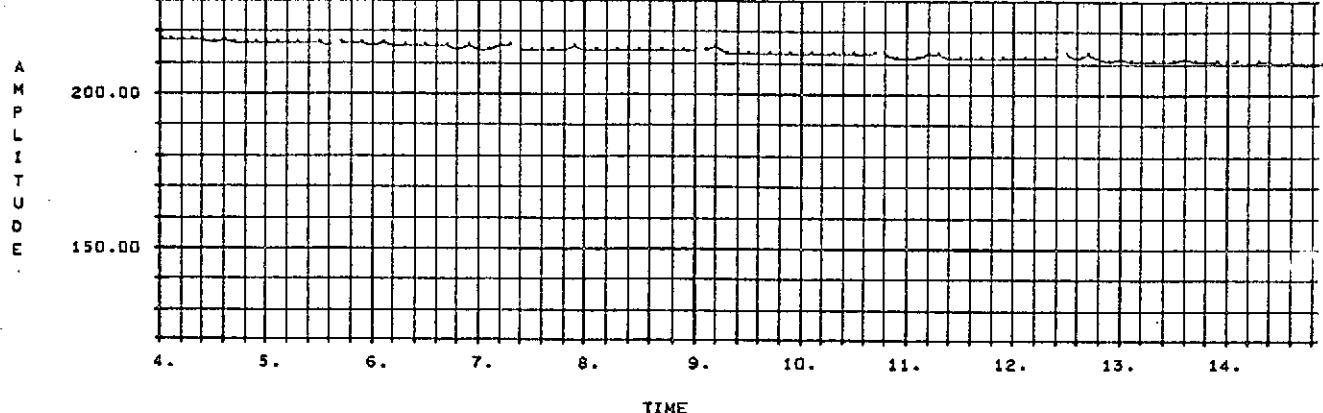
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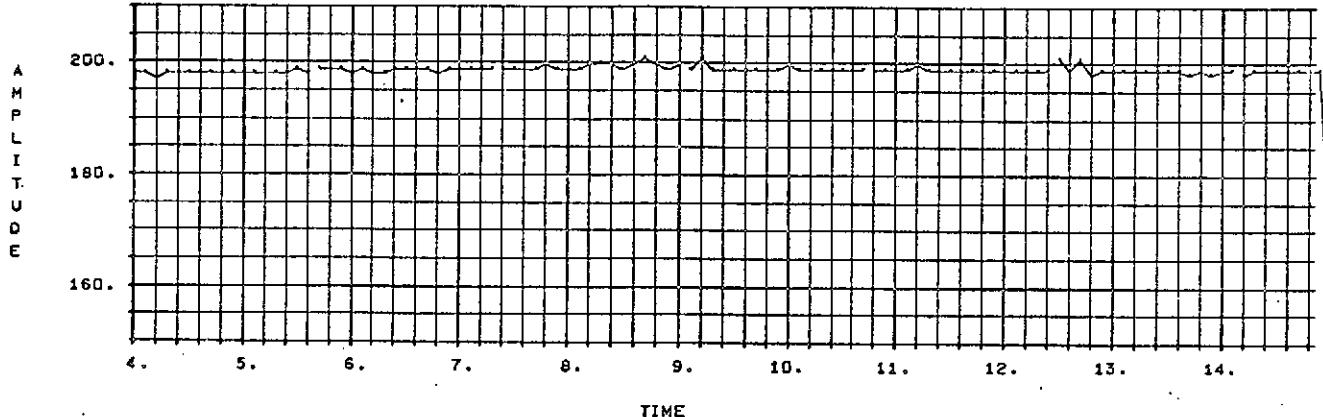


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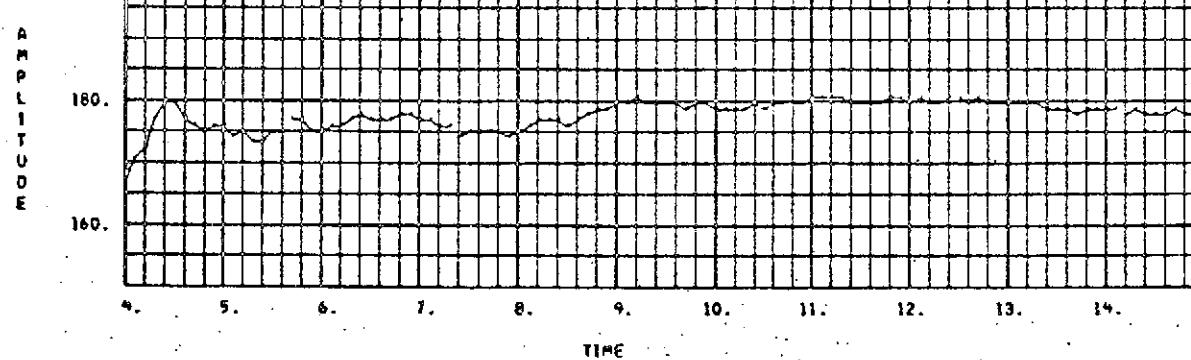
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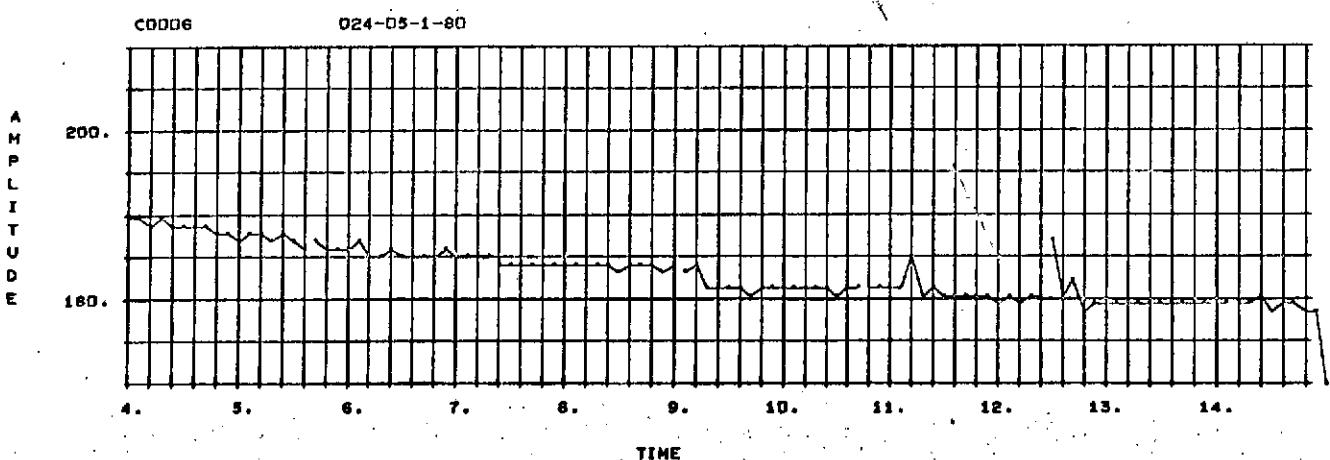
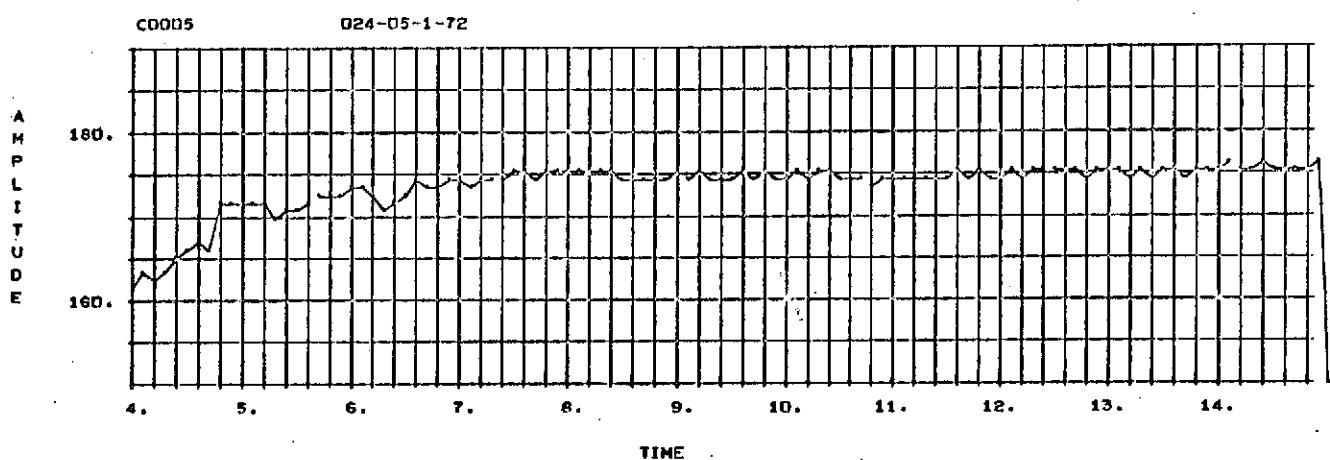
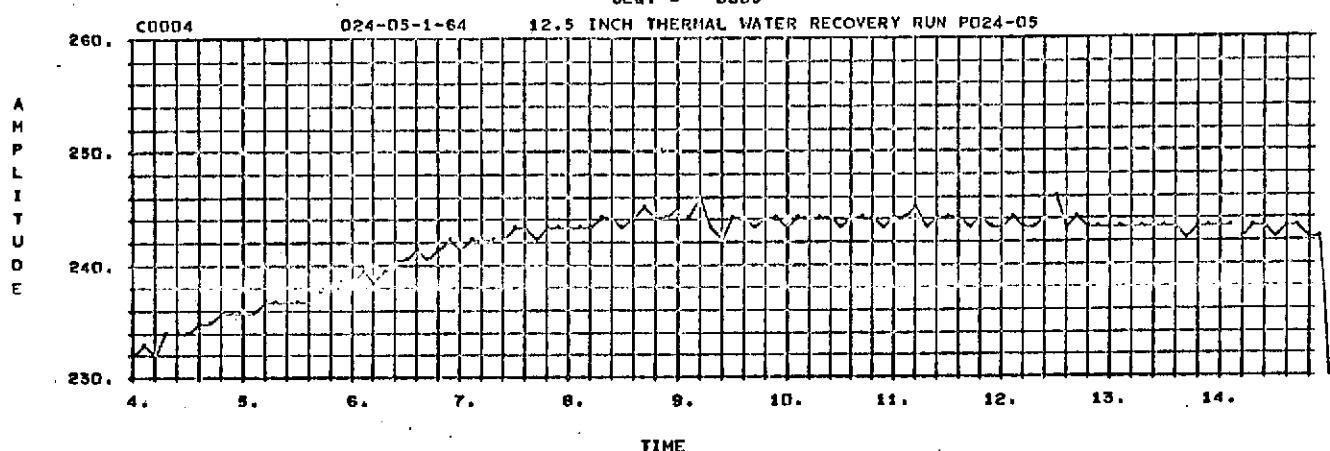
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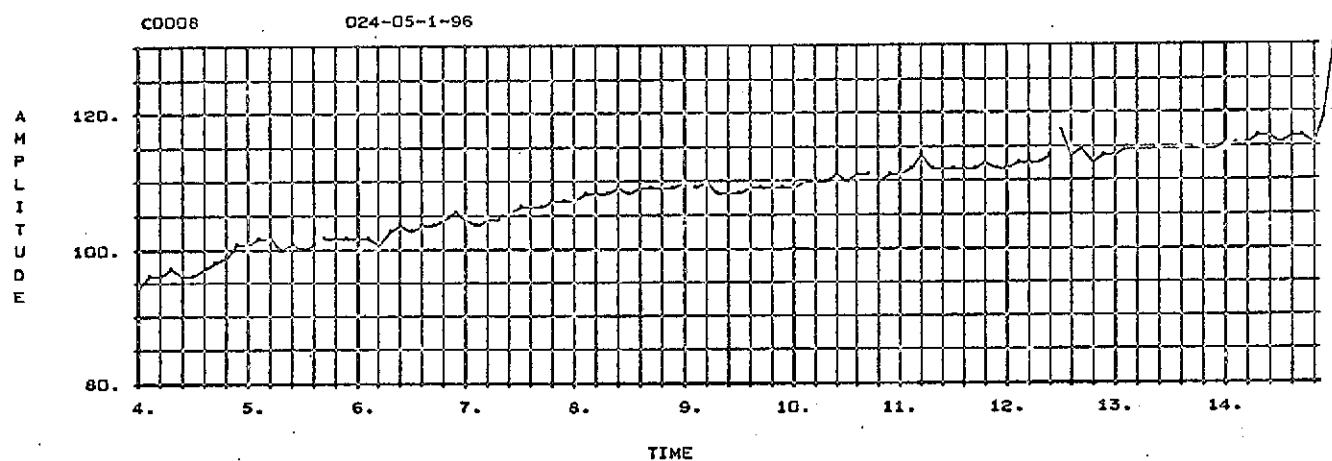
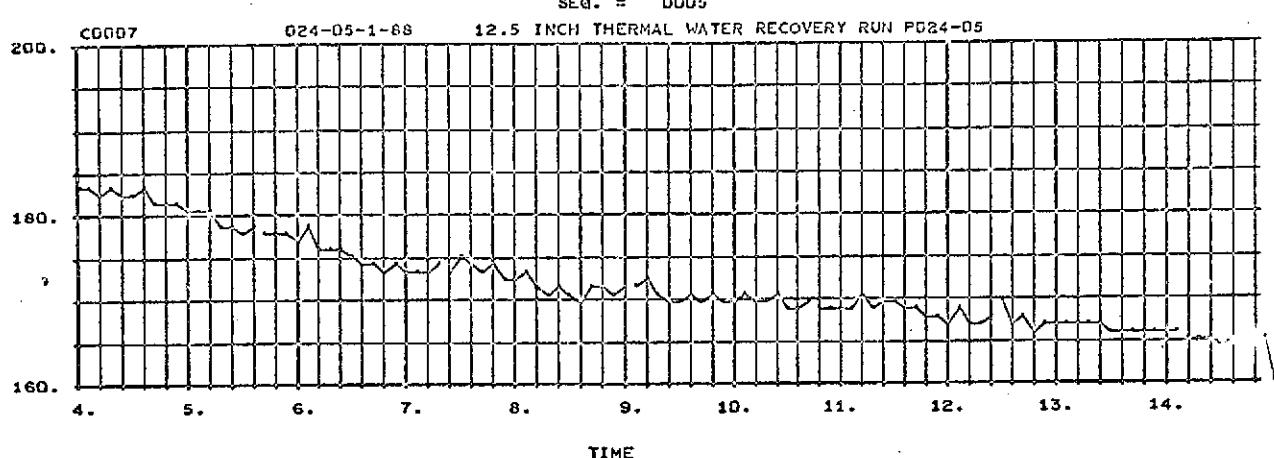


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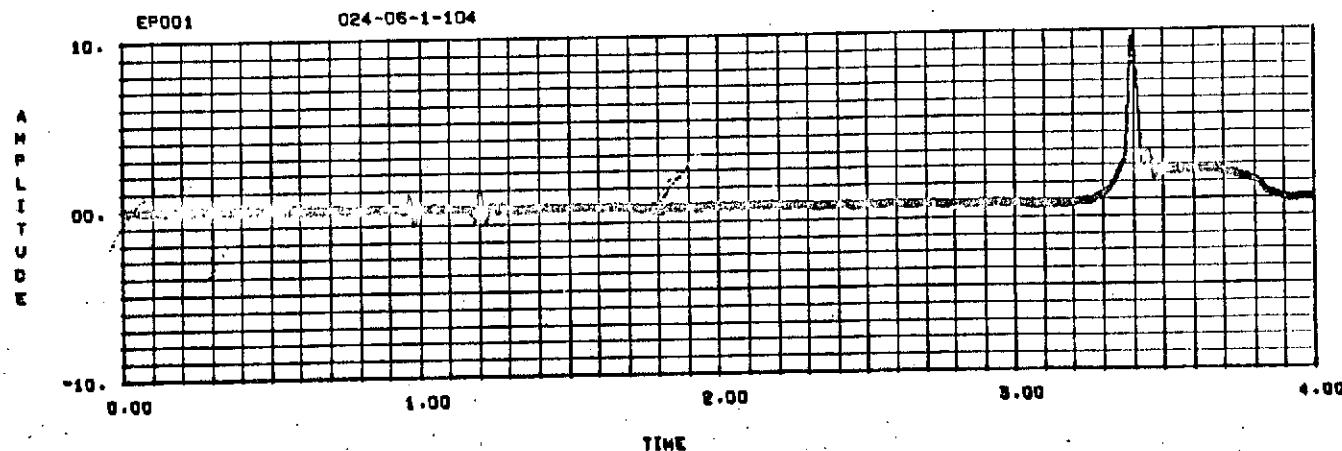
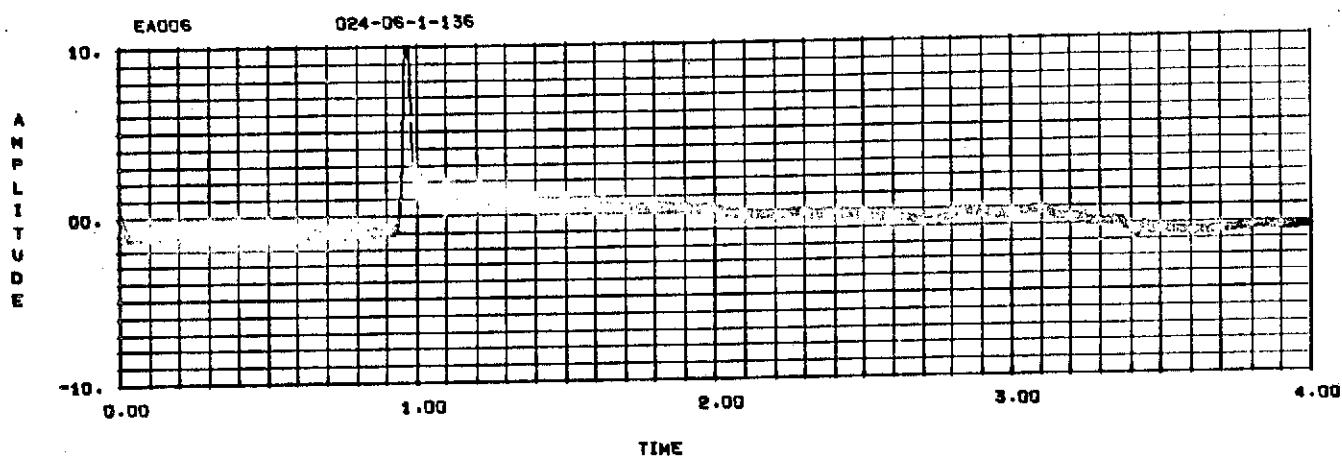
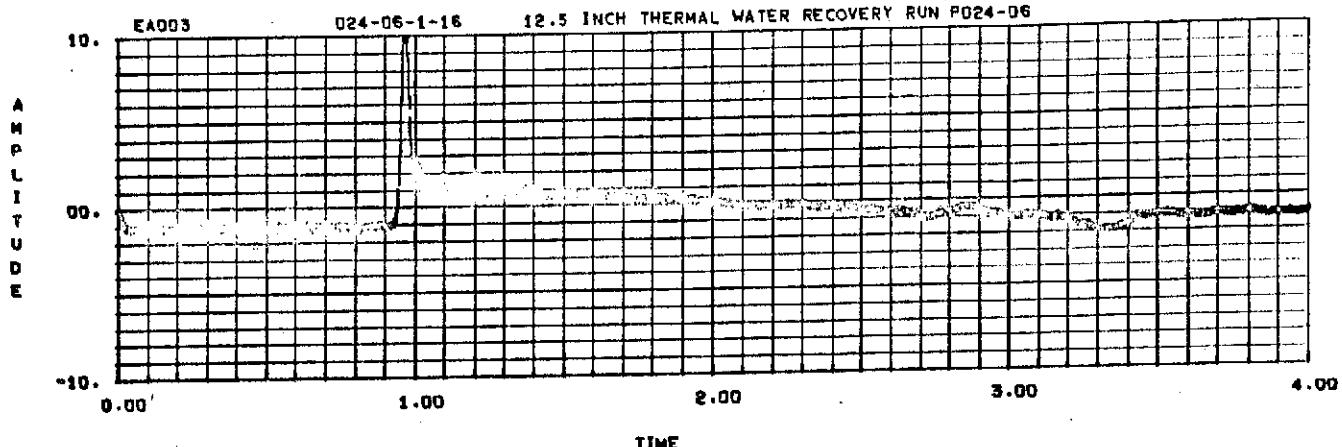
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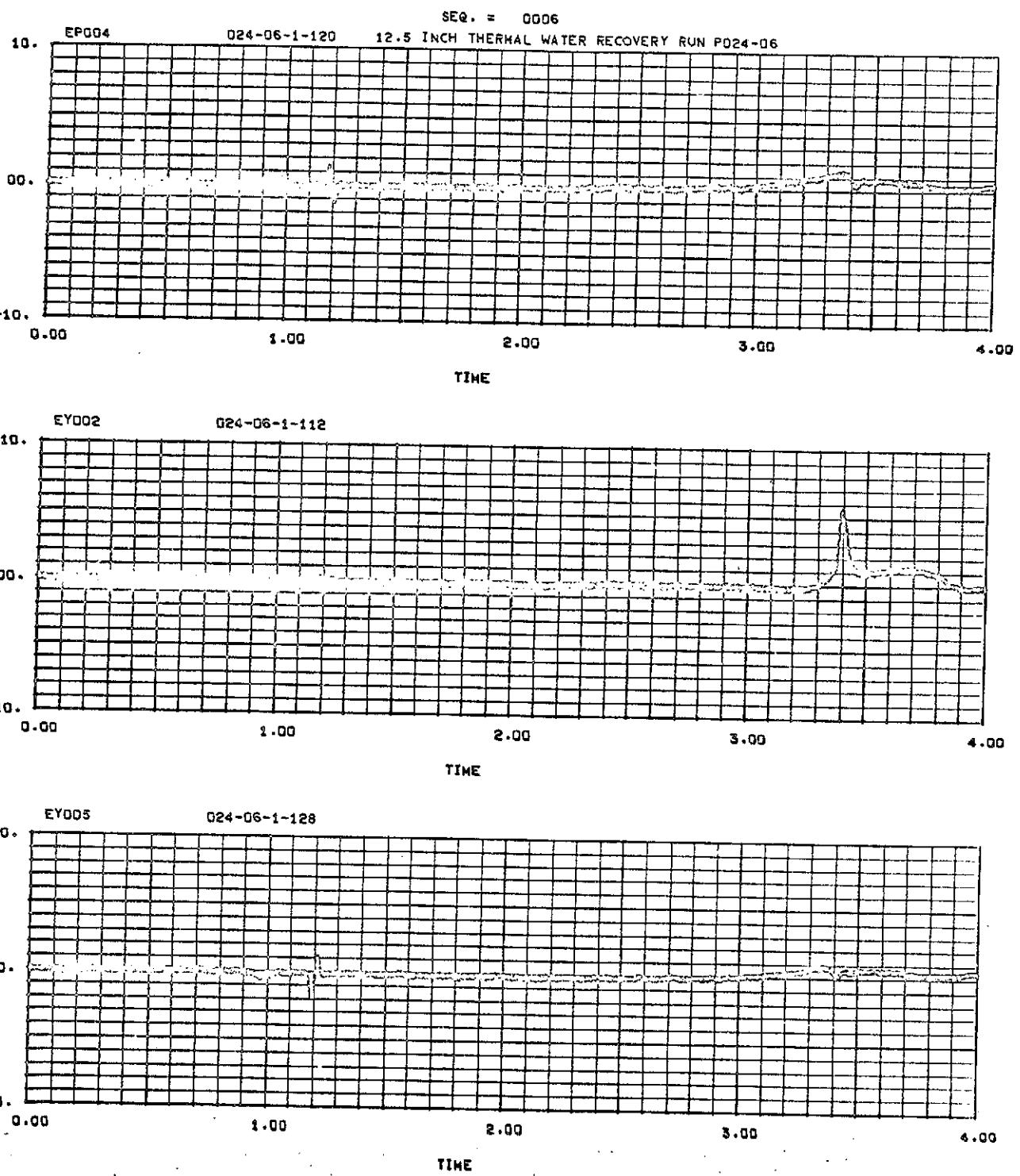
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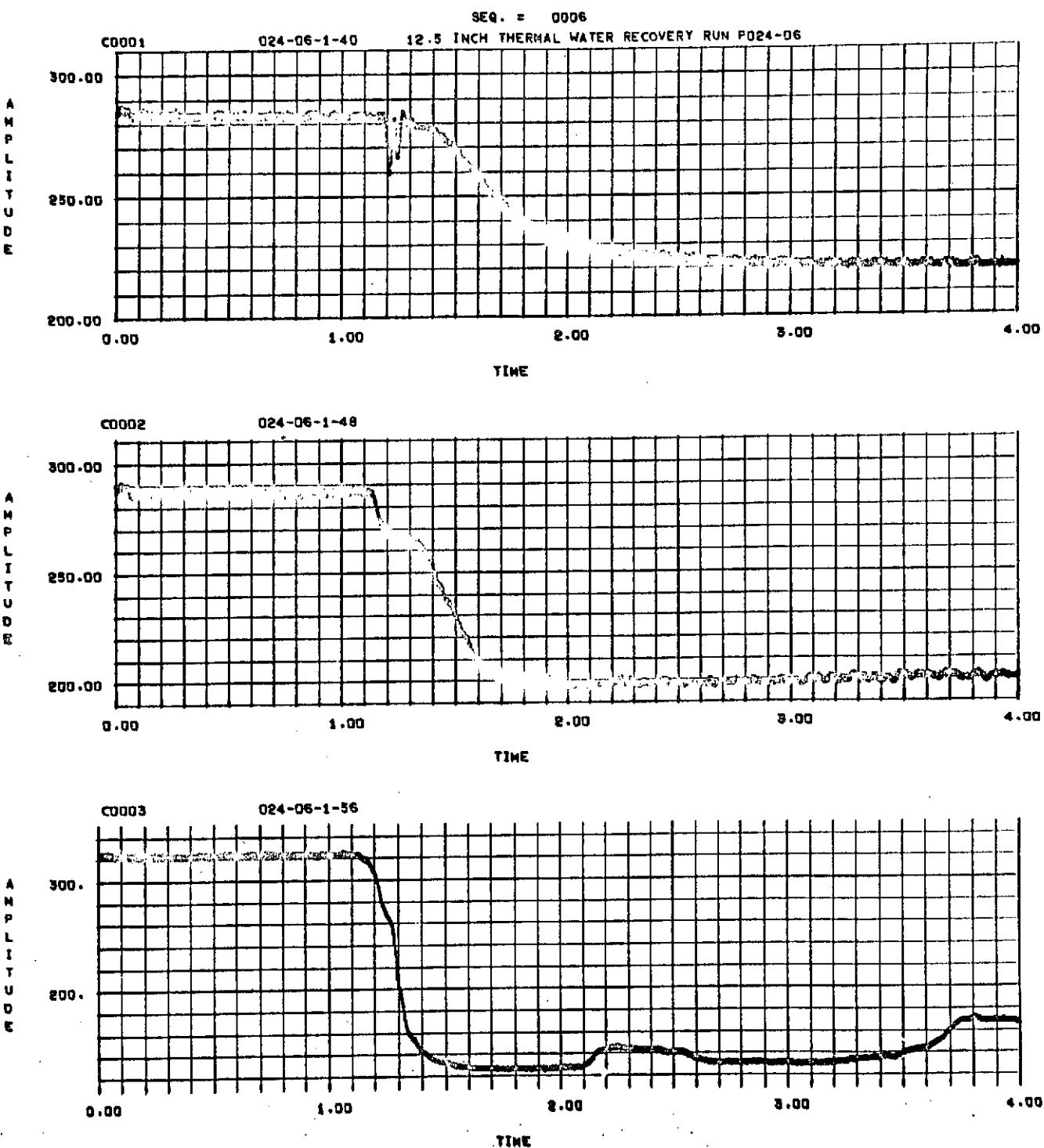


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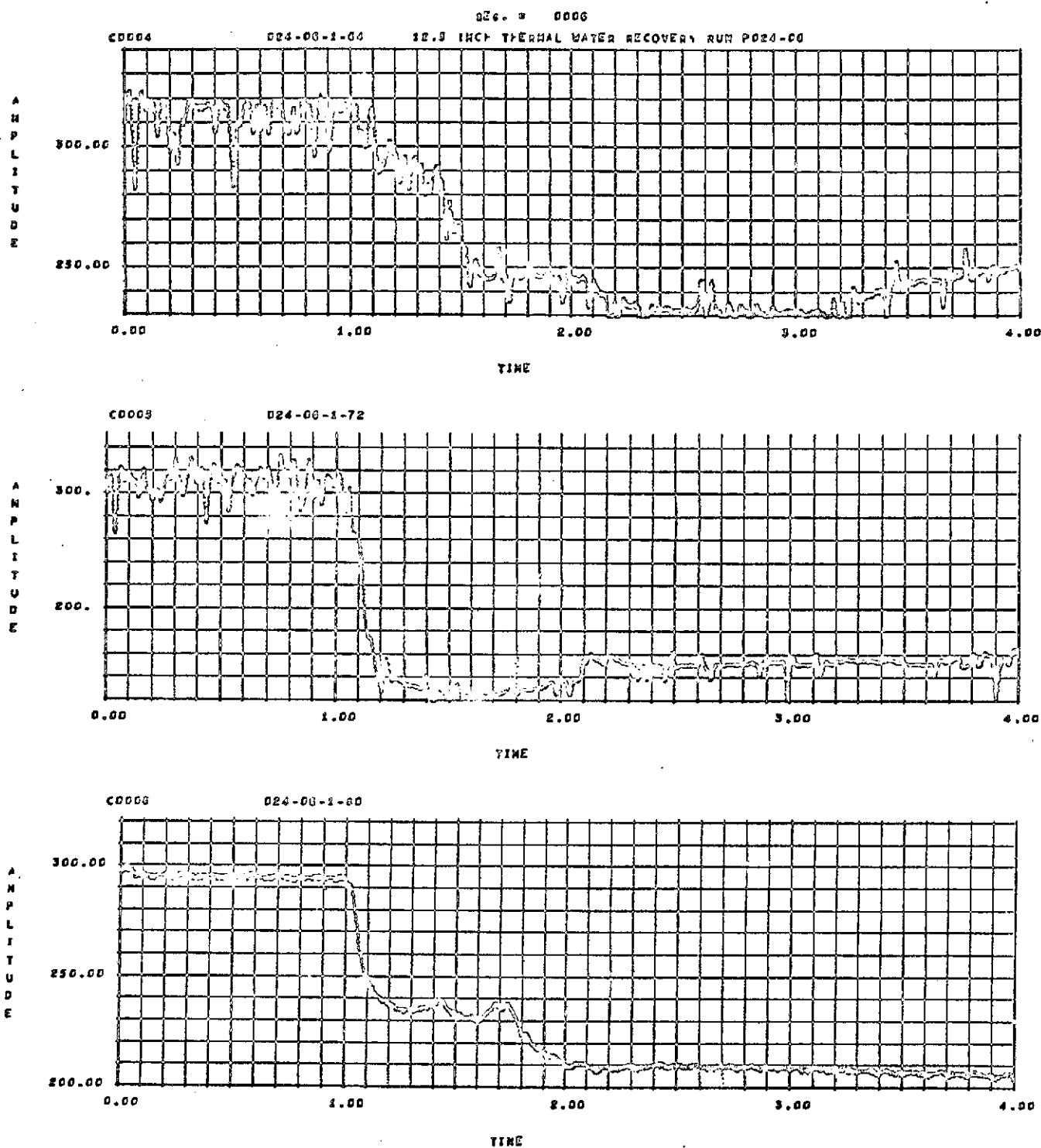
024-06-1-16 12.5 INCH THERMAL WATER RECOVERY RUN P024-06

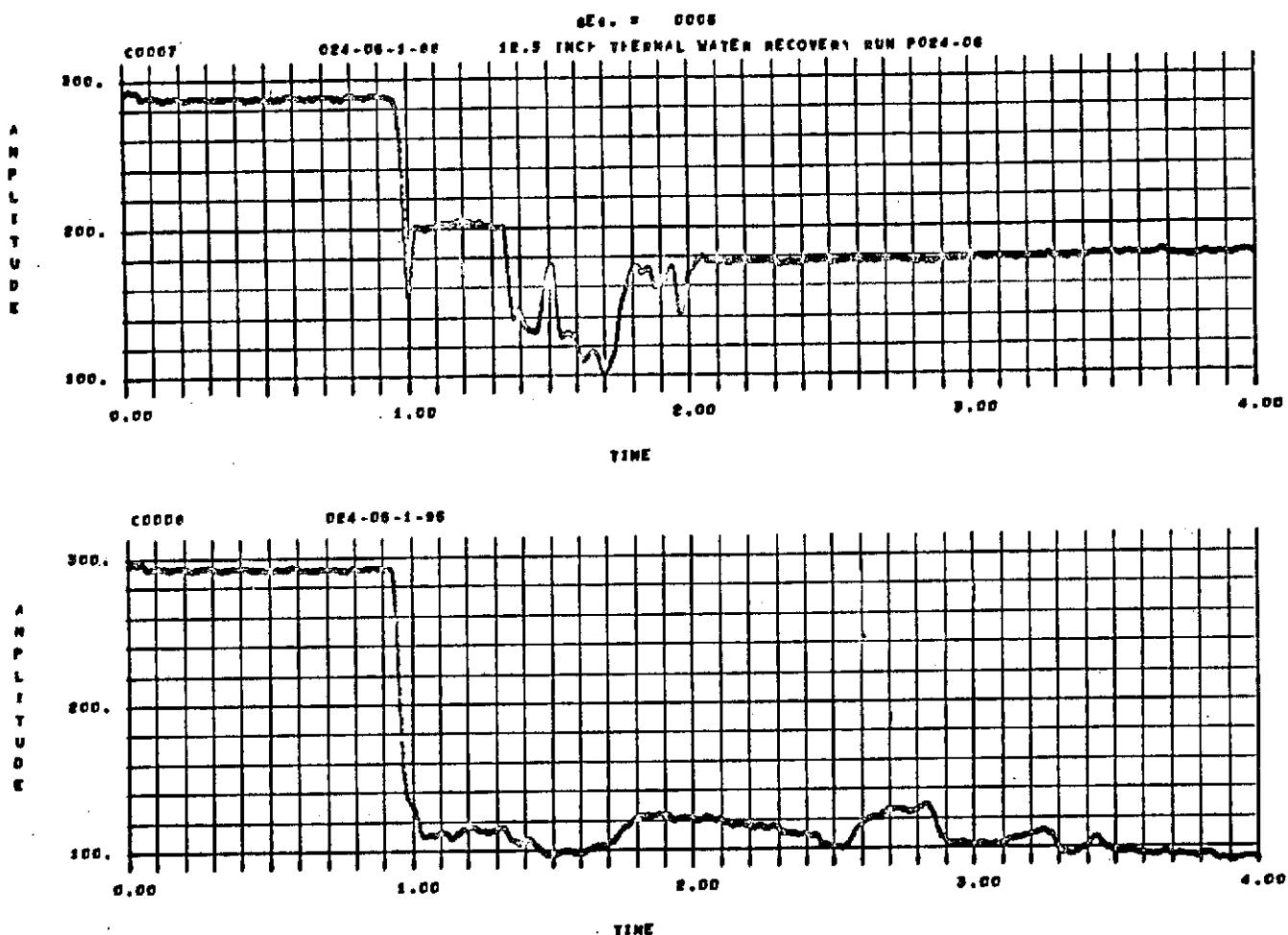




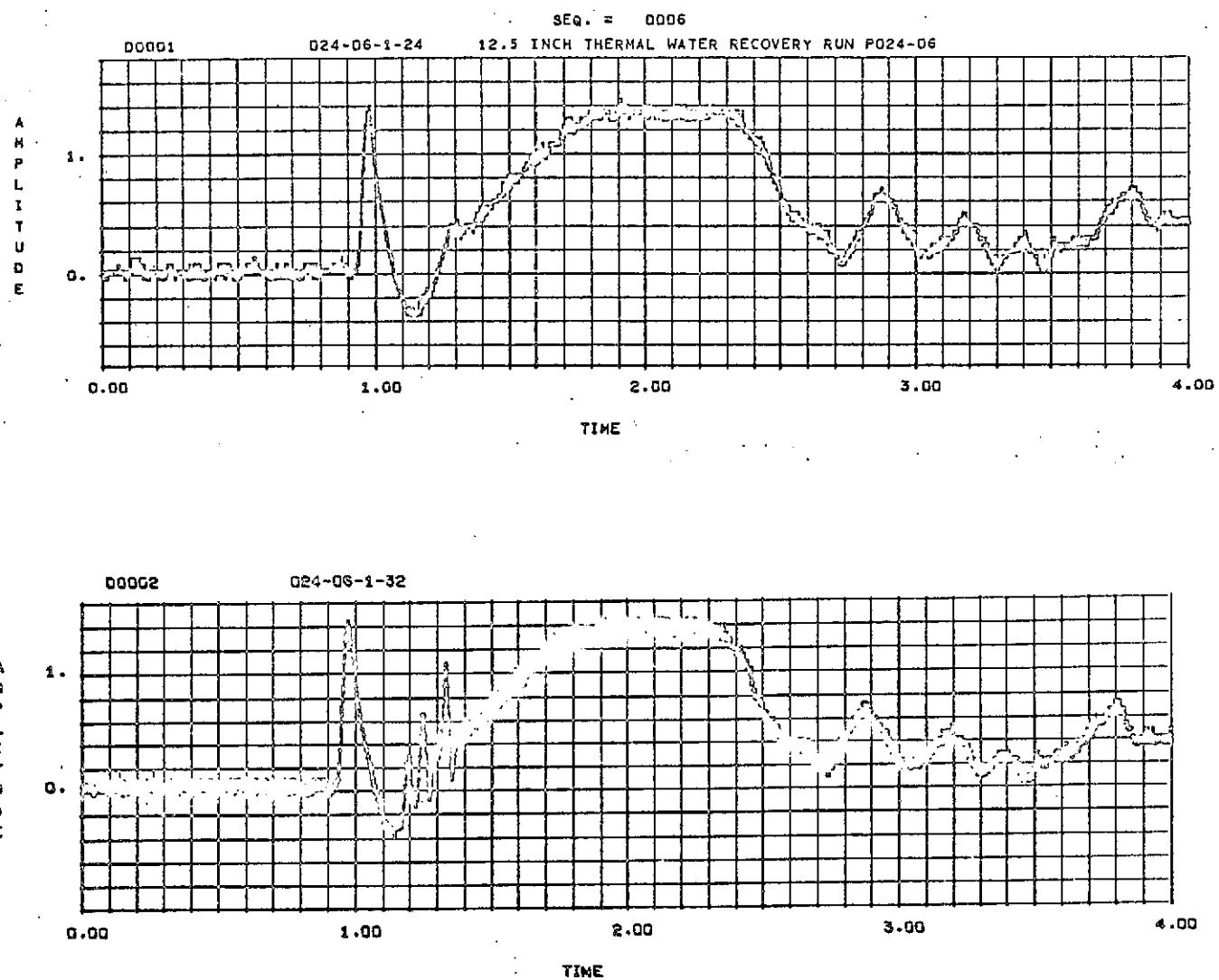


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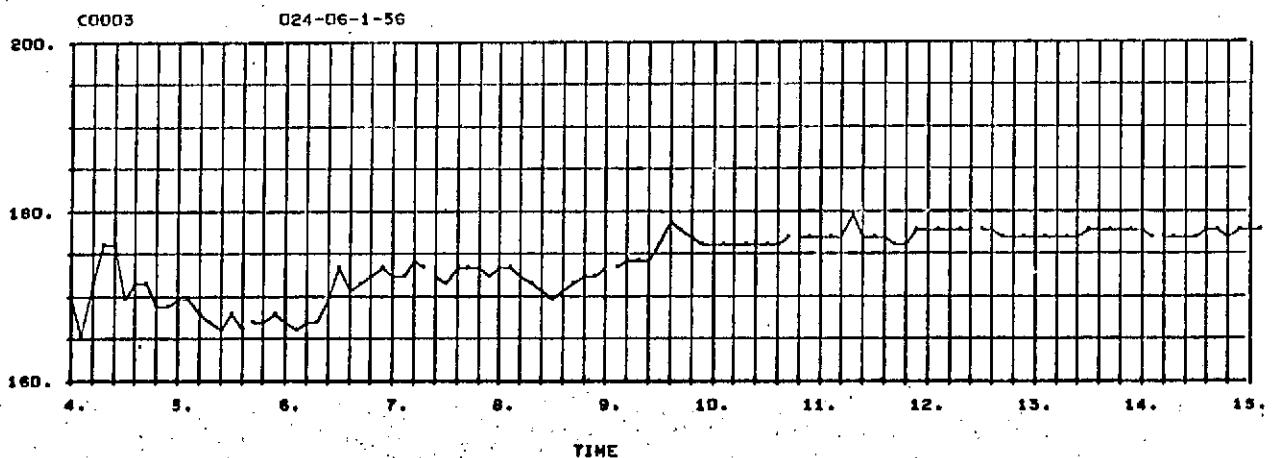
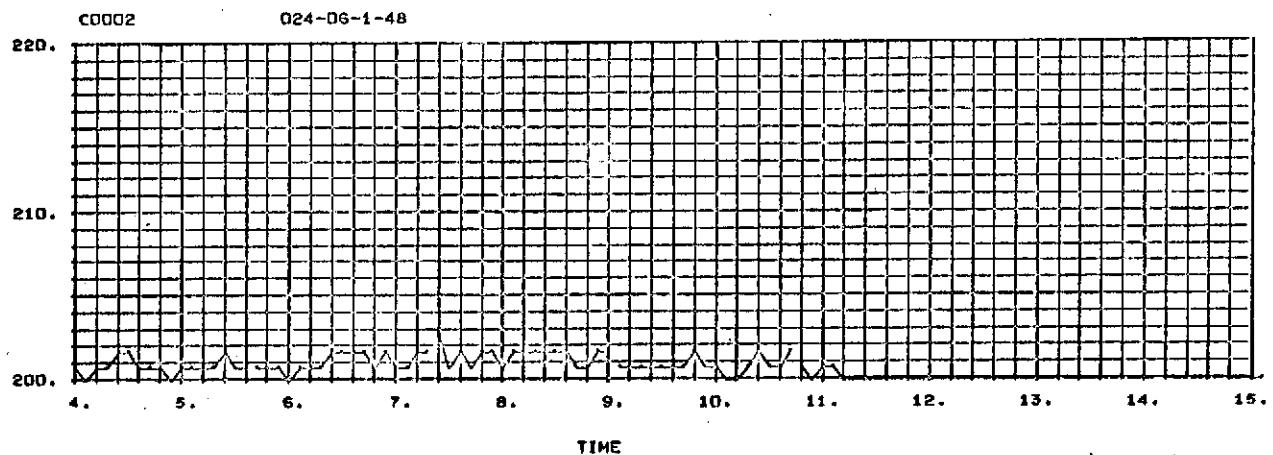
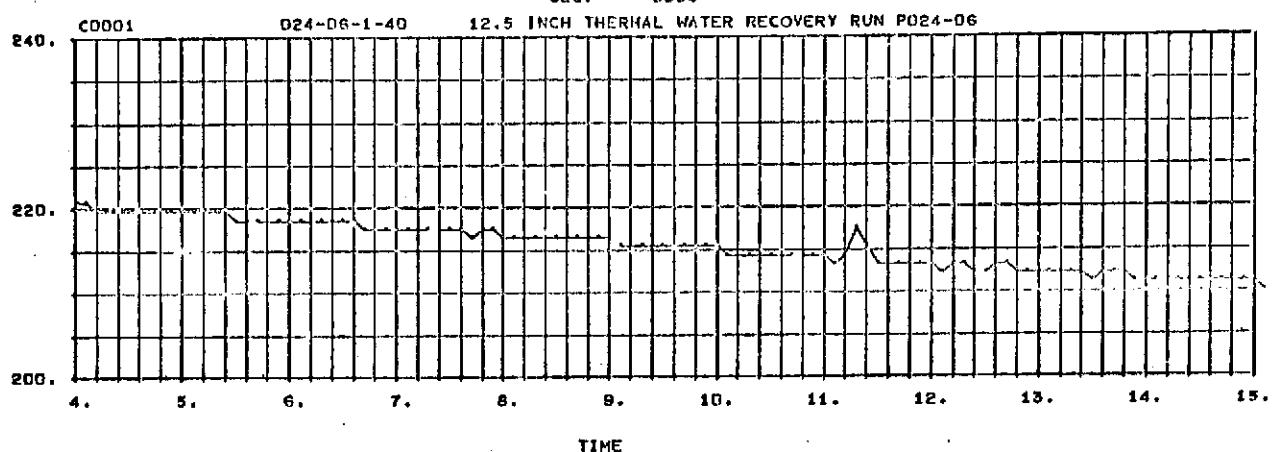


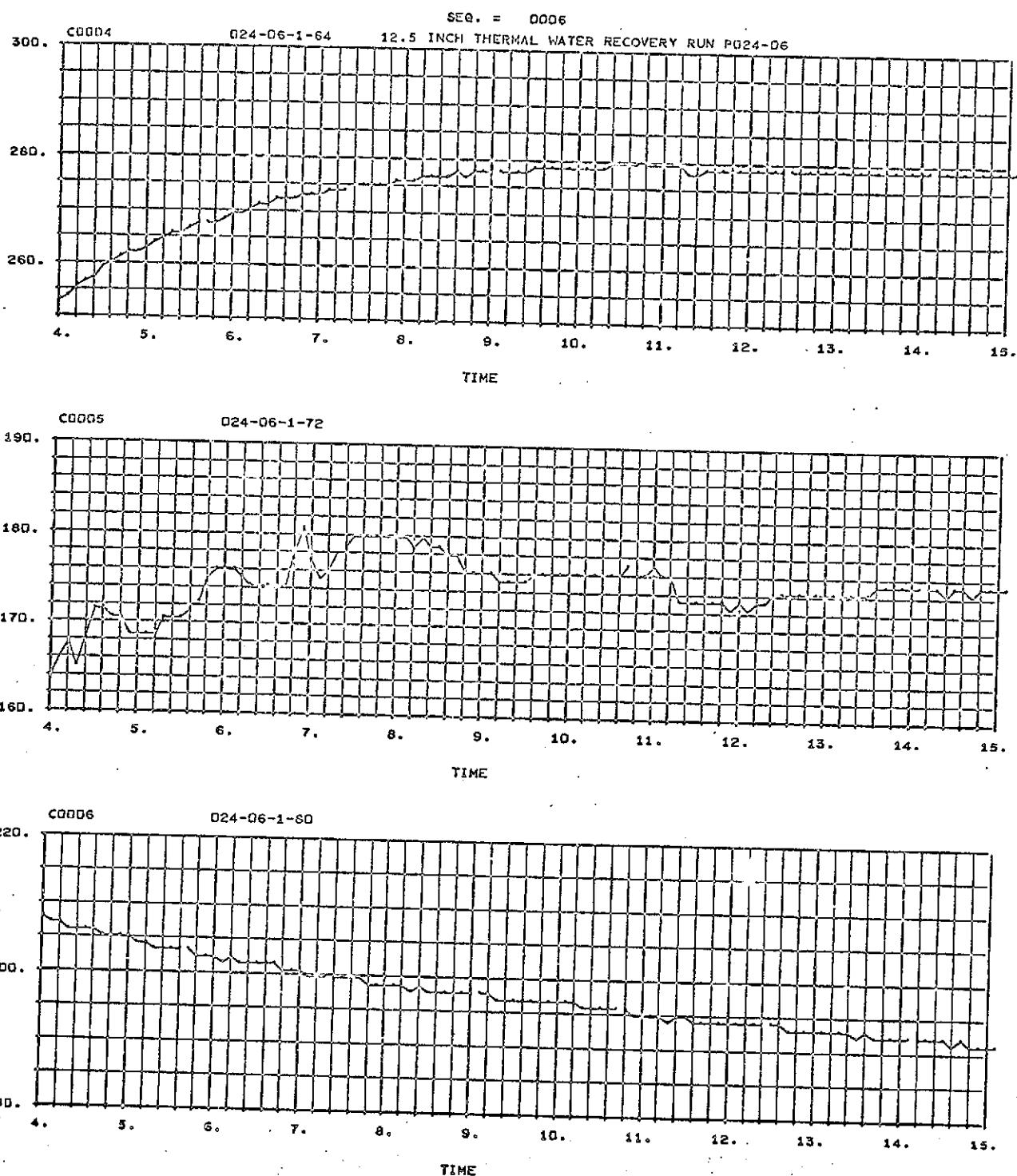


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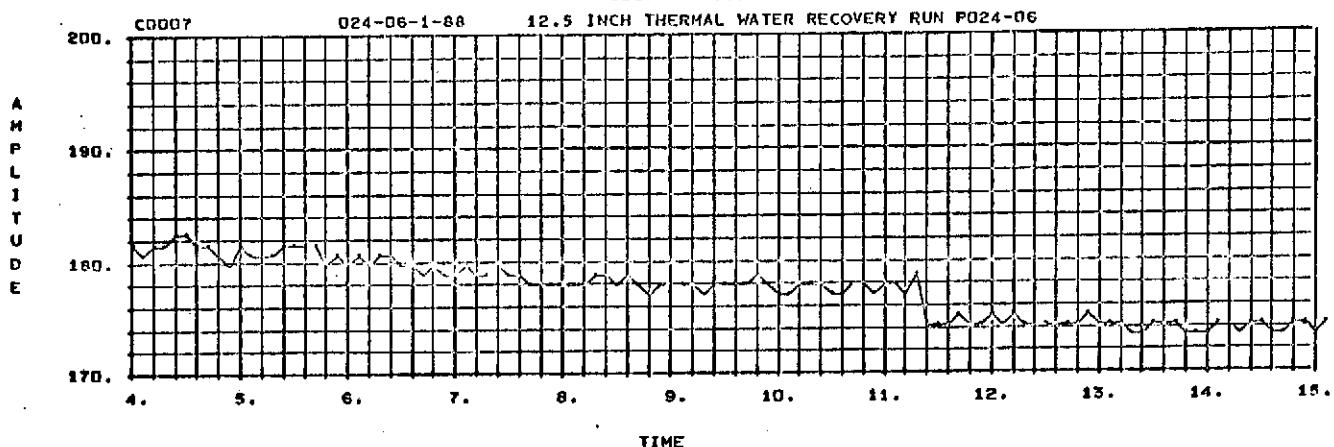
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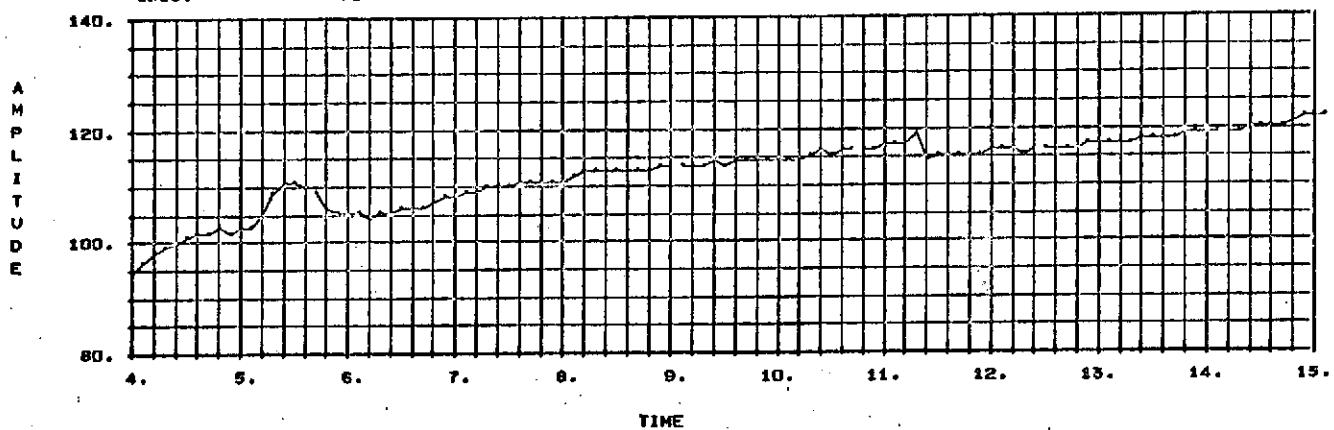


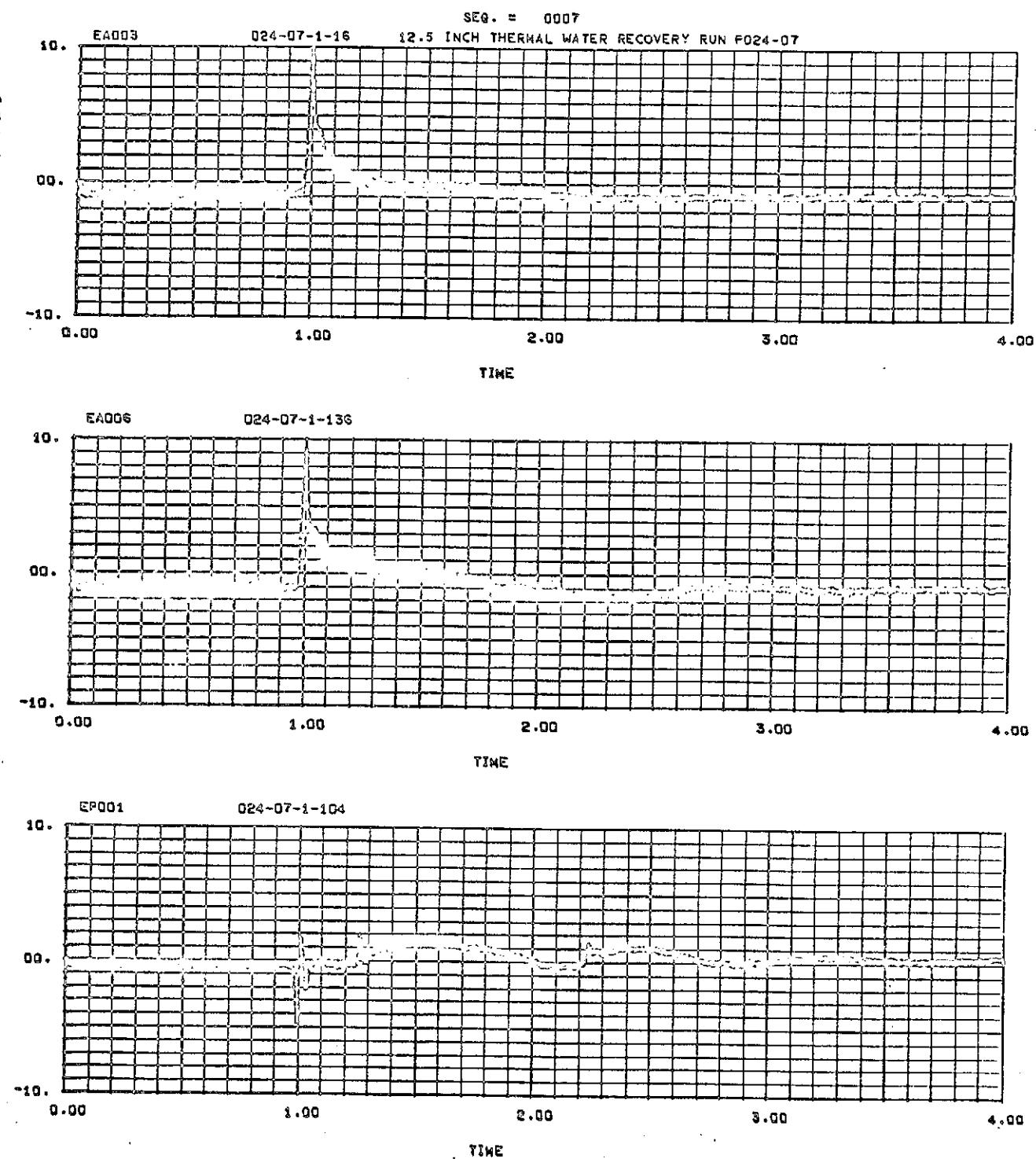
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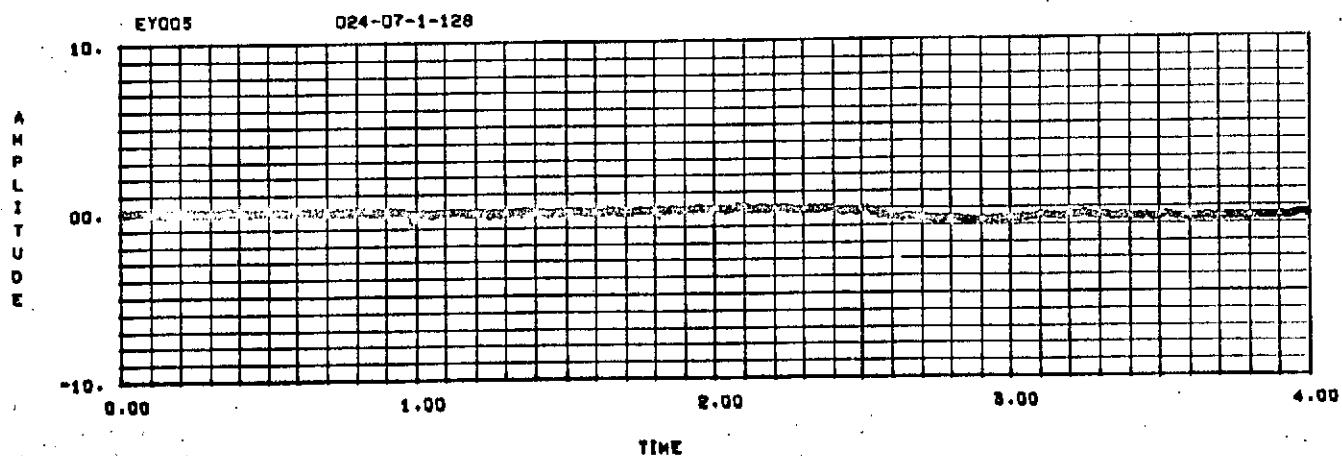
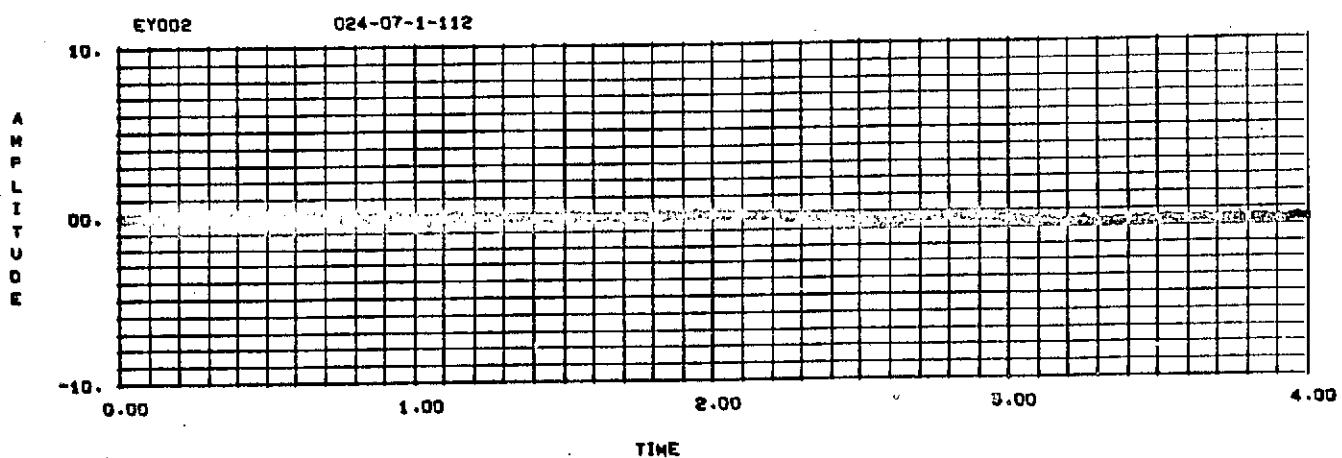
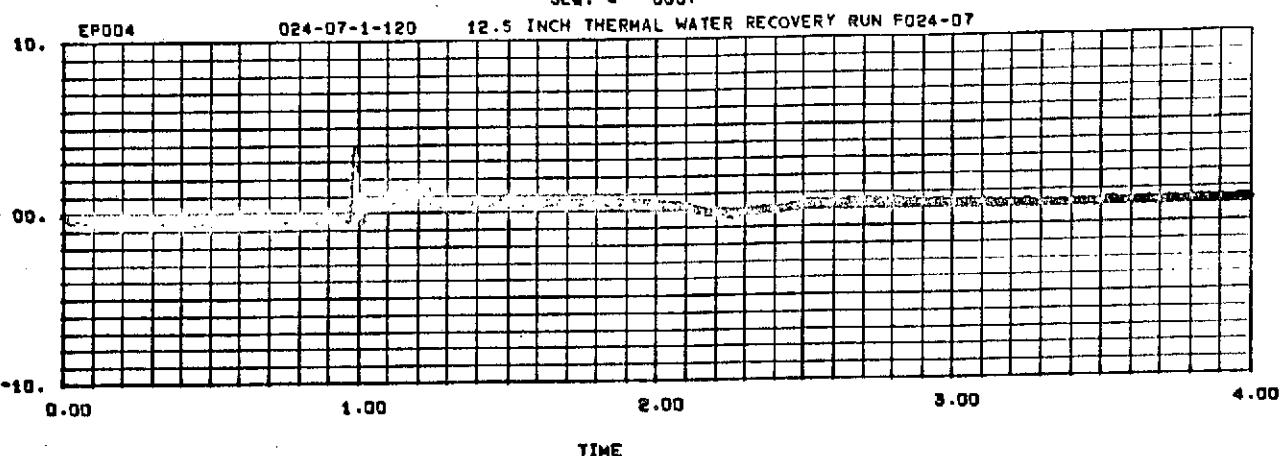


C0008 024-06-1-96



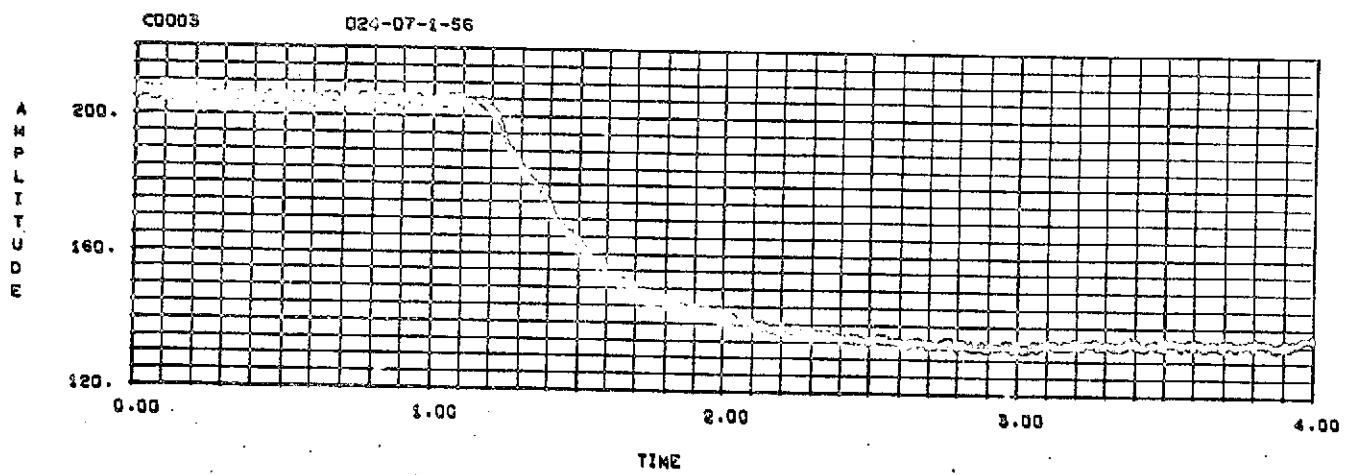
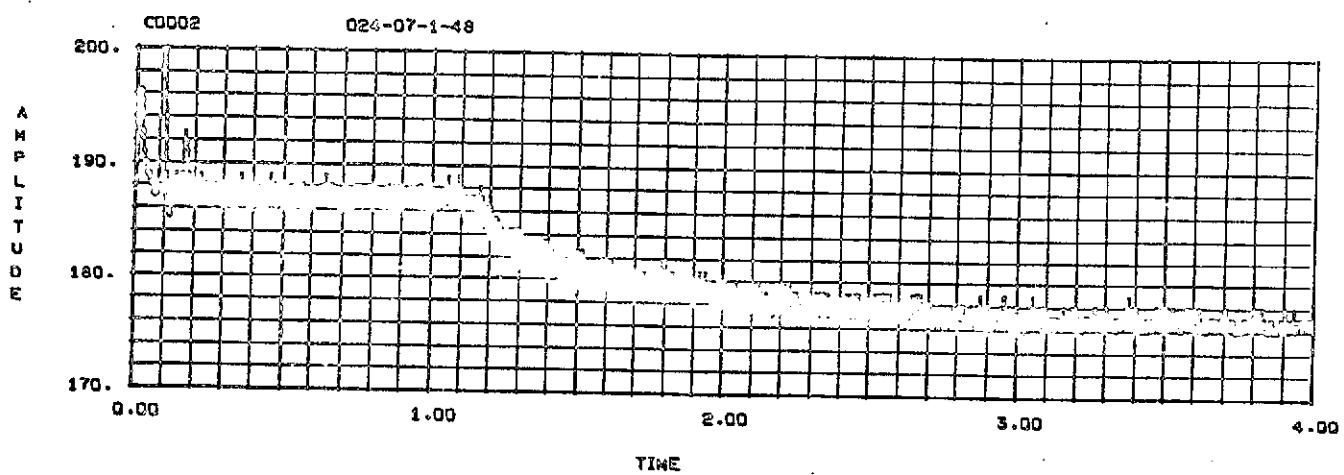
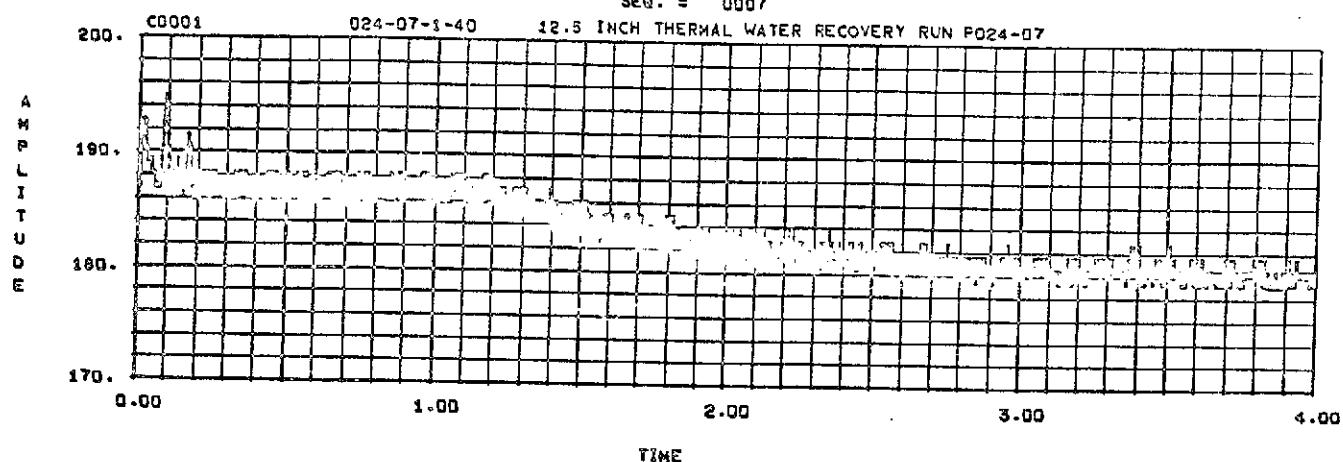


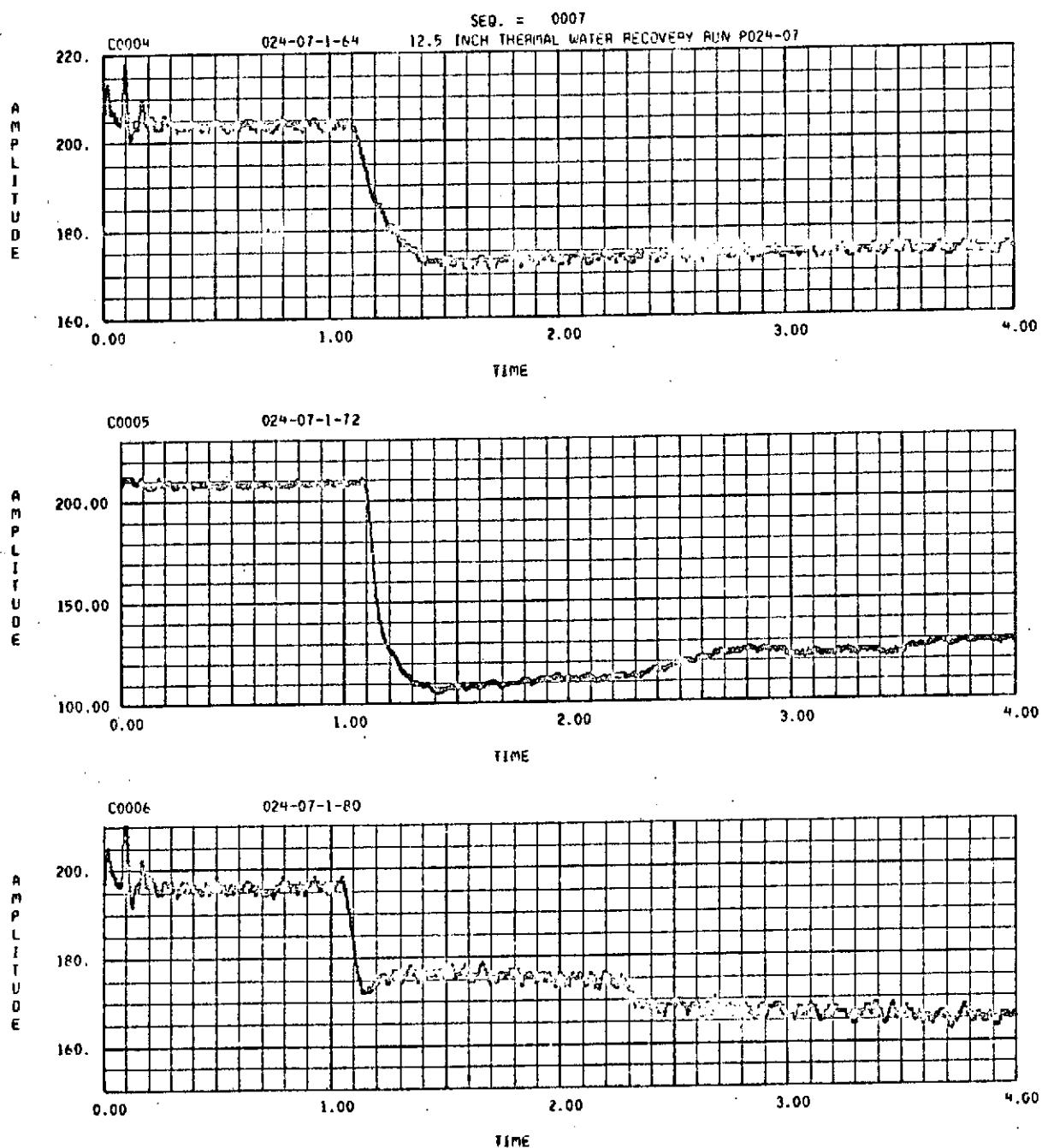
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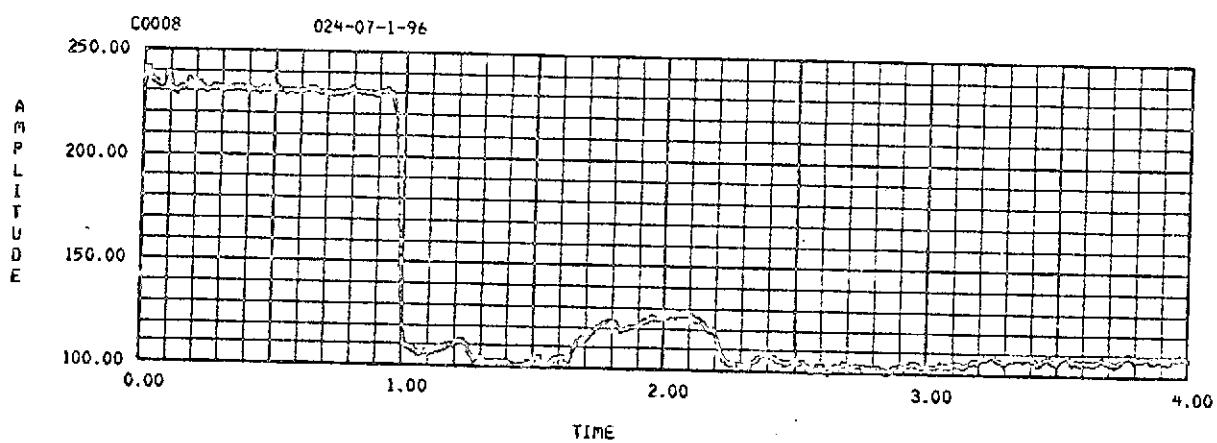
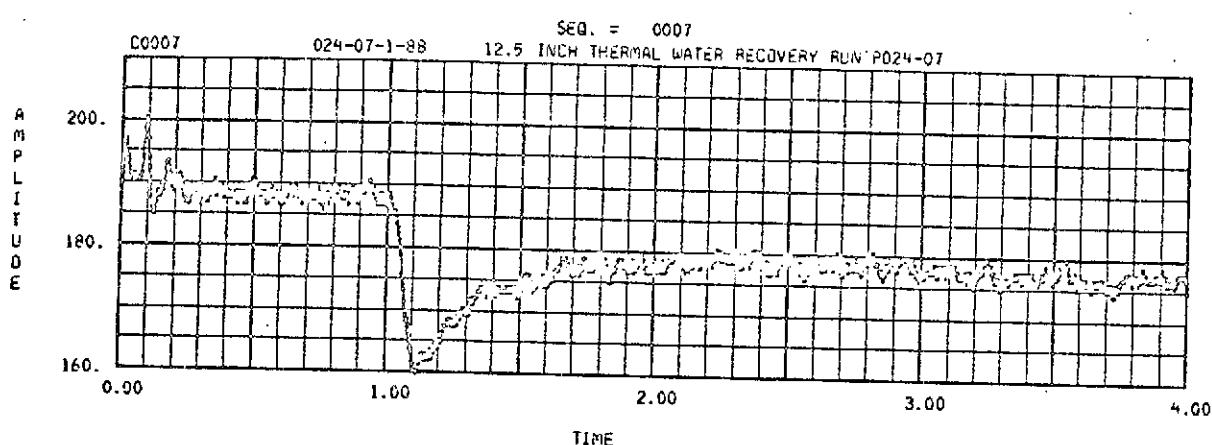
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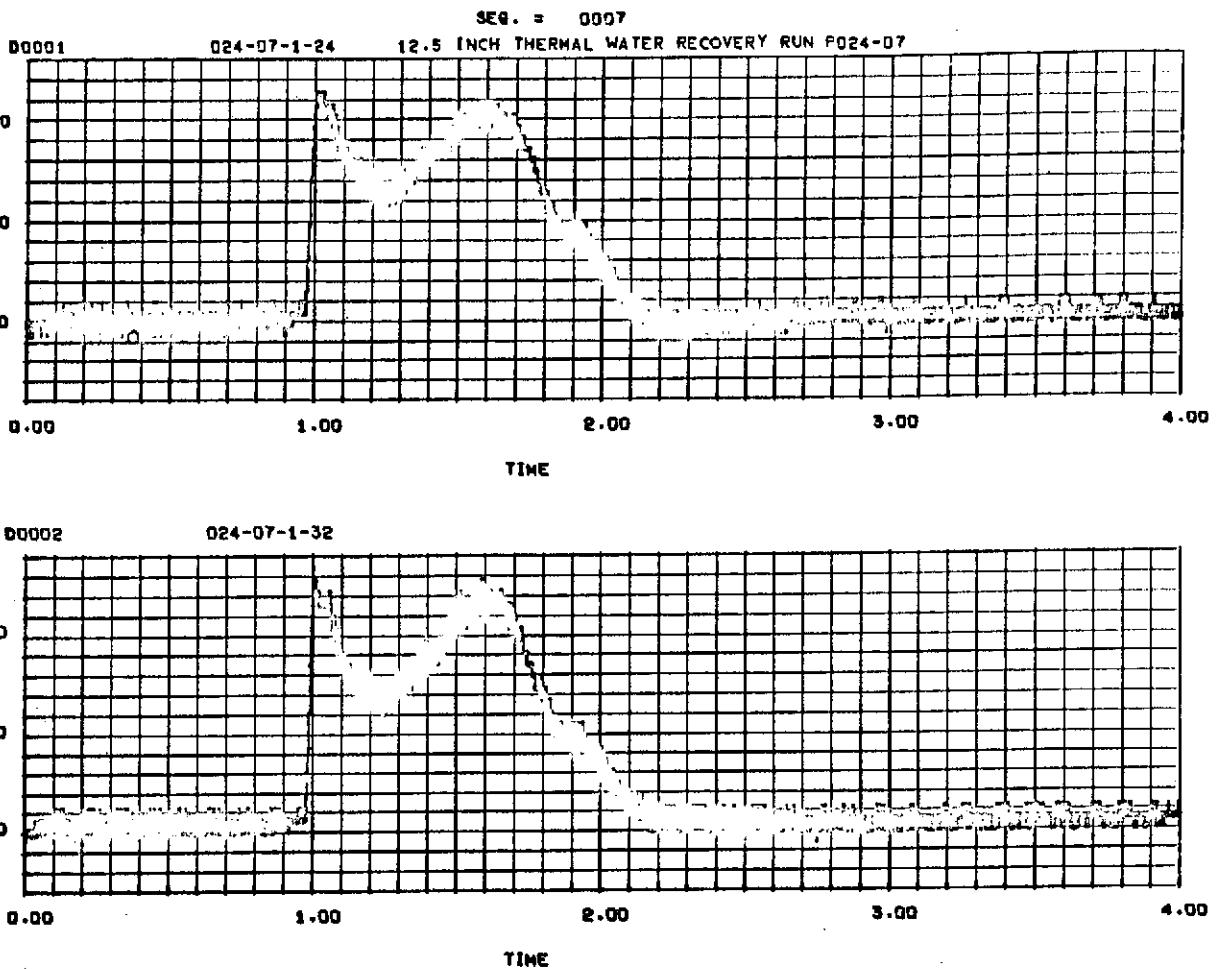
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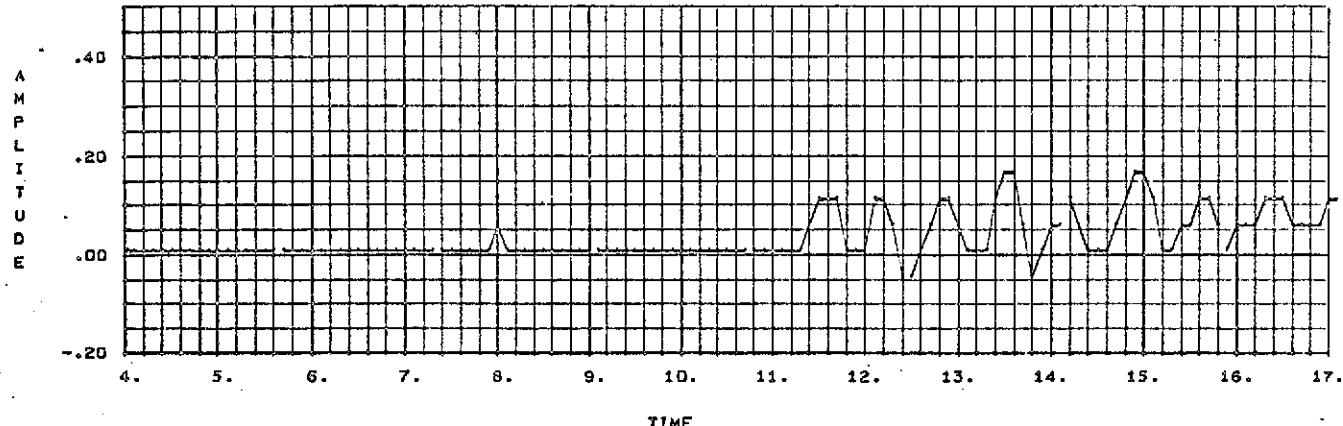
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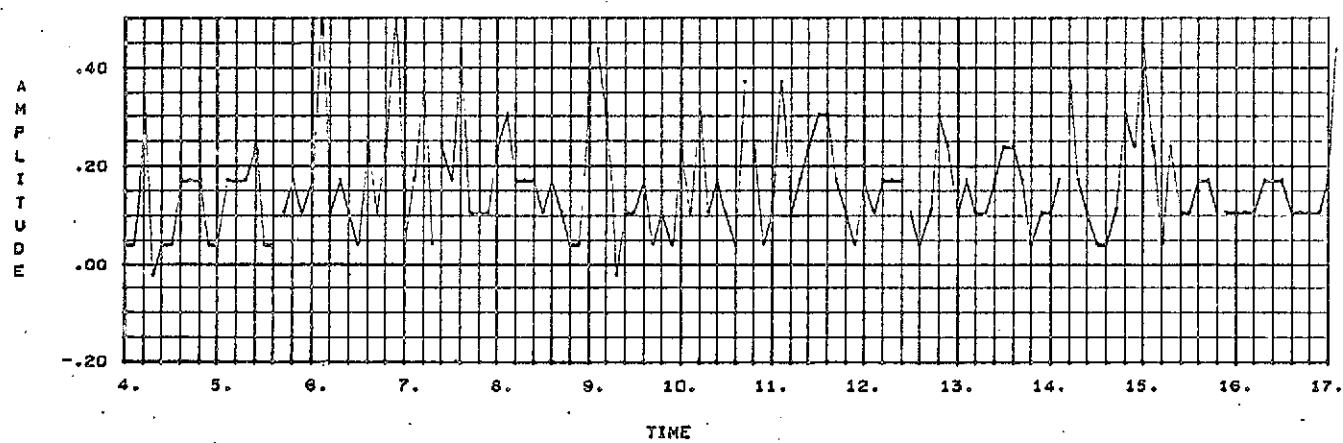
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12.5 INCH THERMAL WATER RECOVERY RUN P024-07

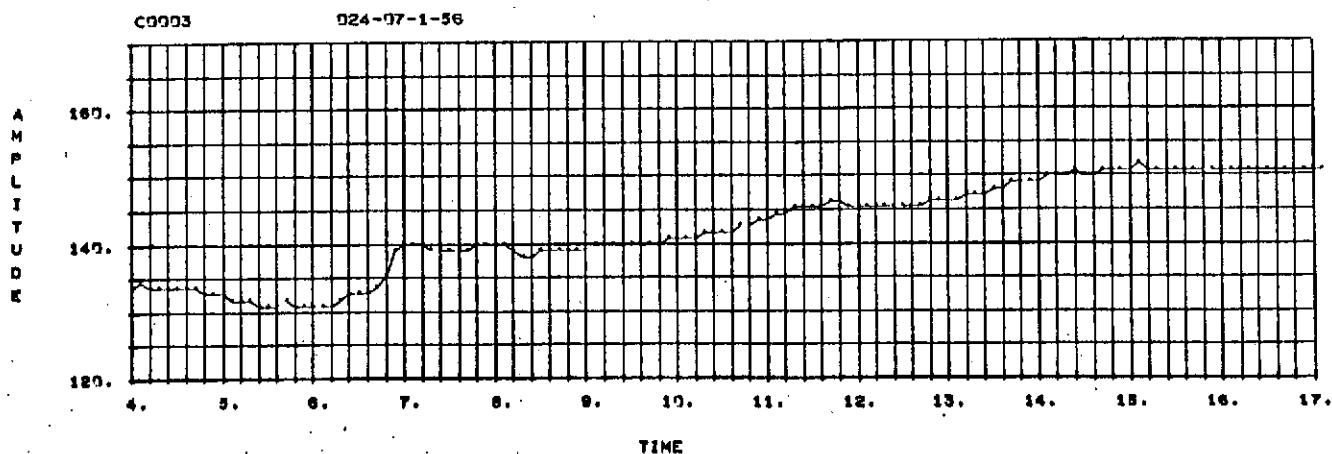
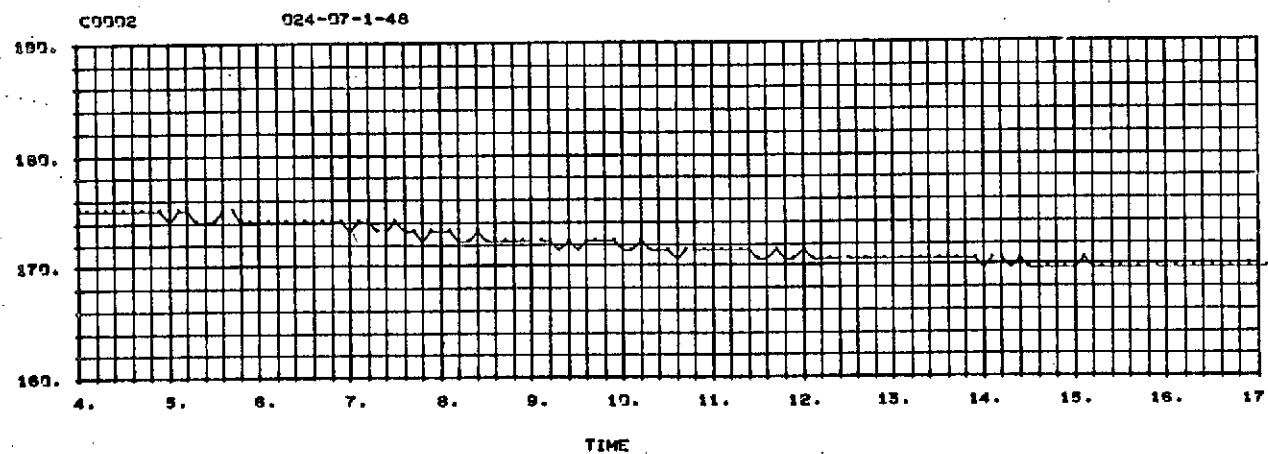
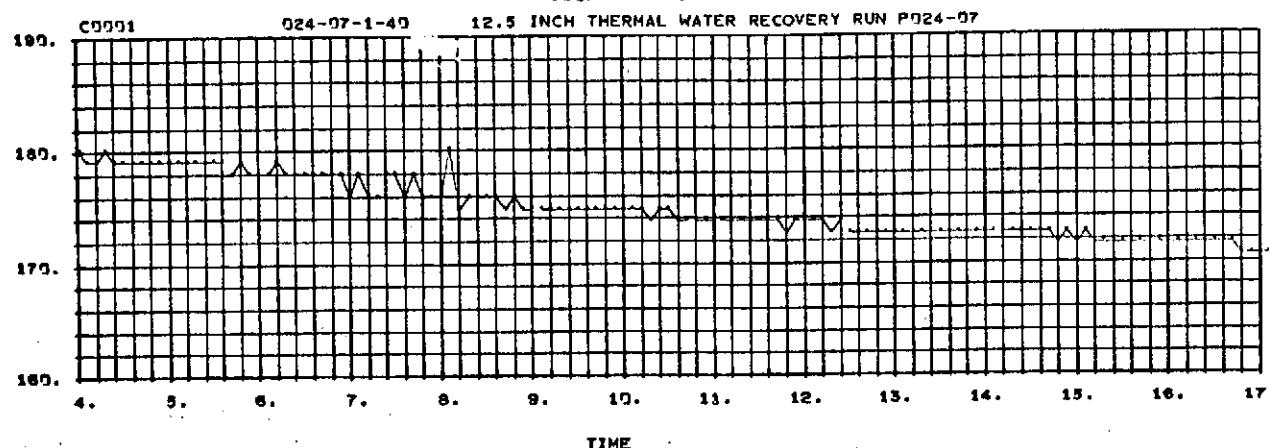


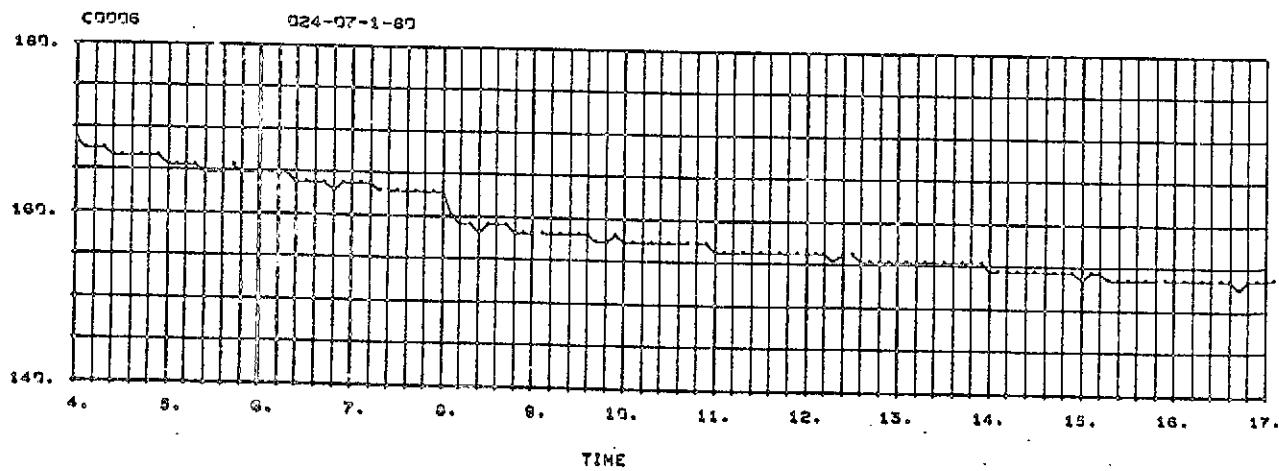
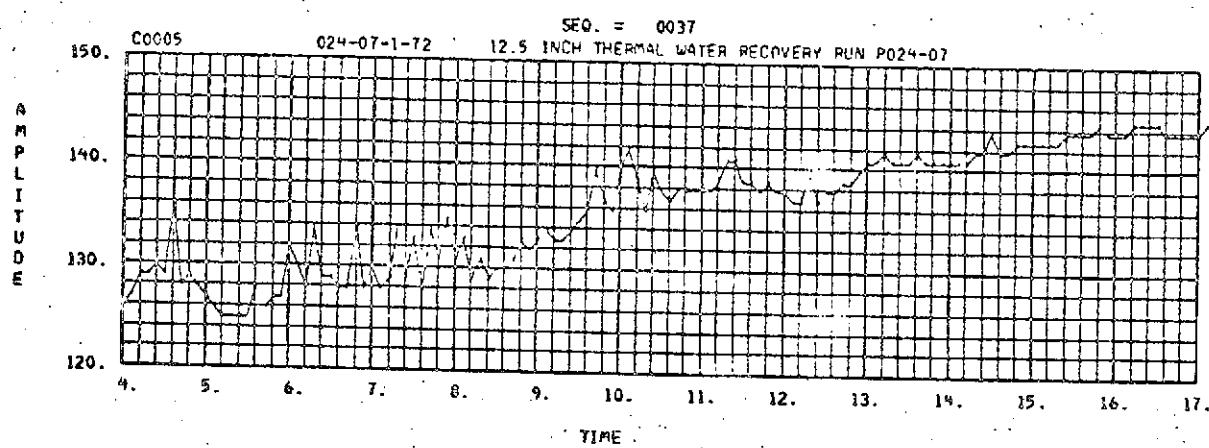
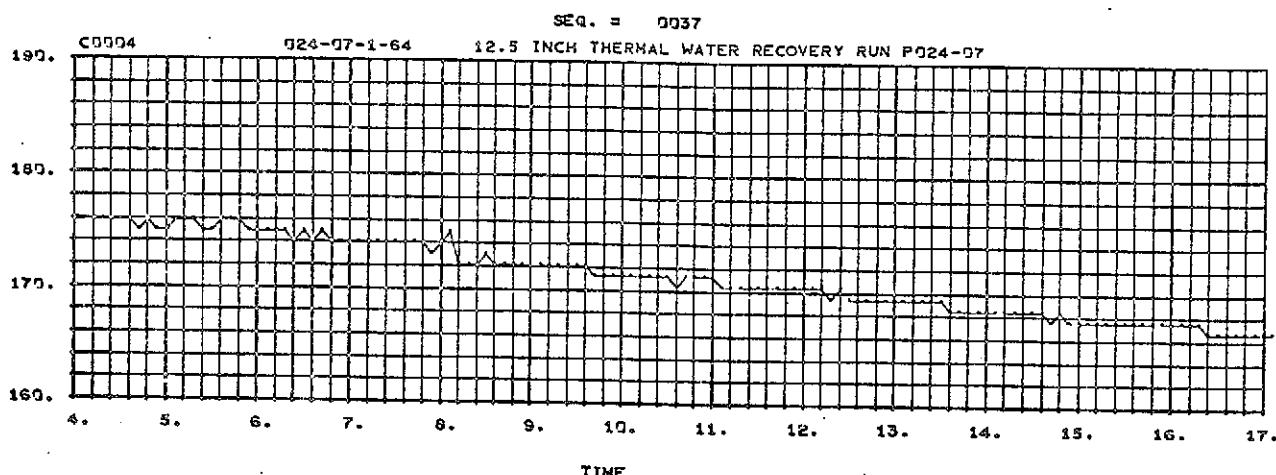
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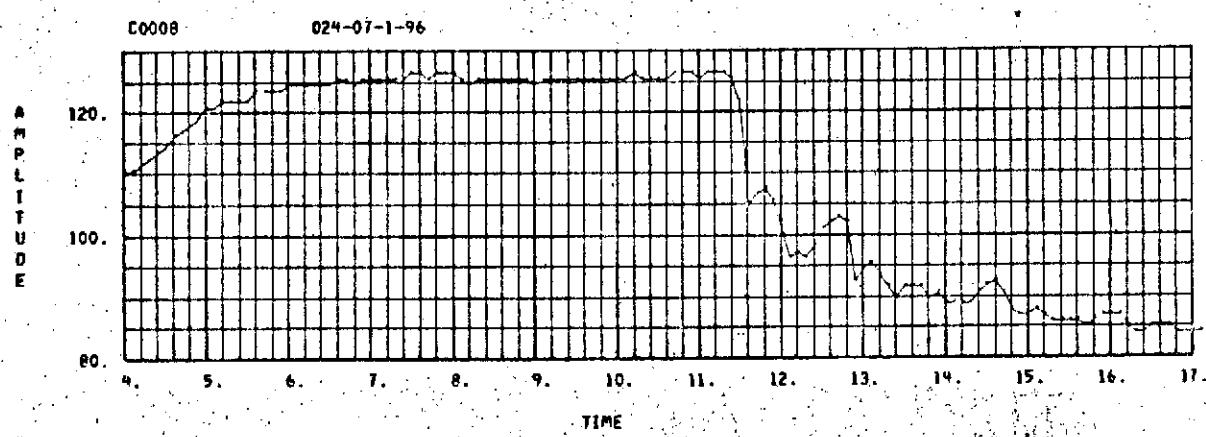
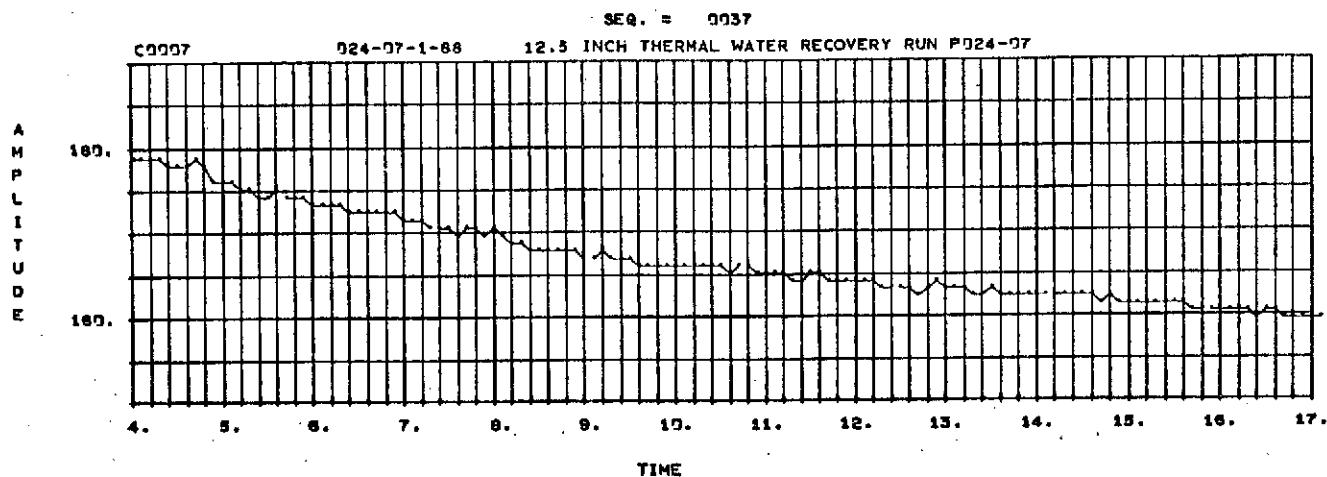
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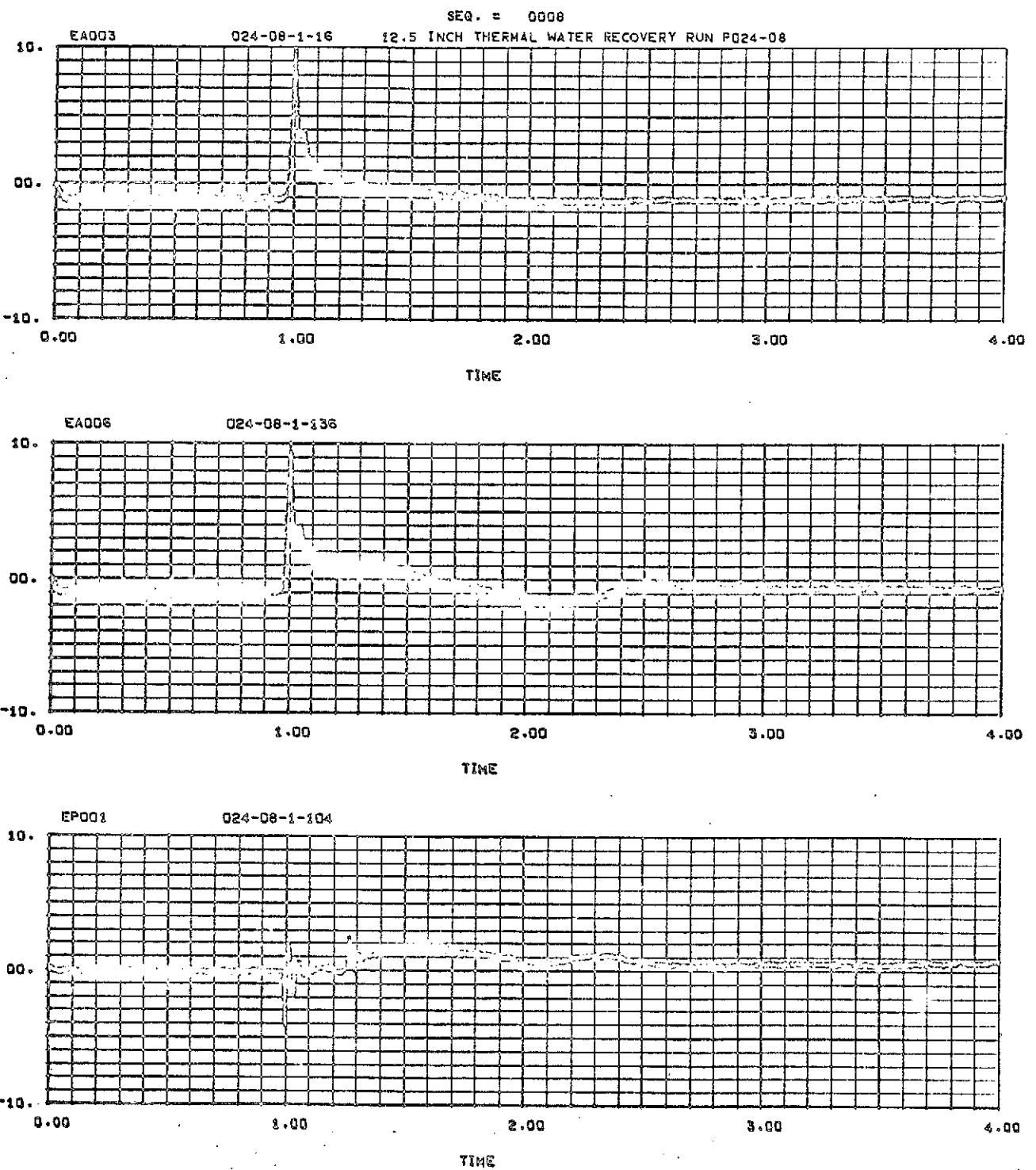
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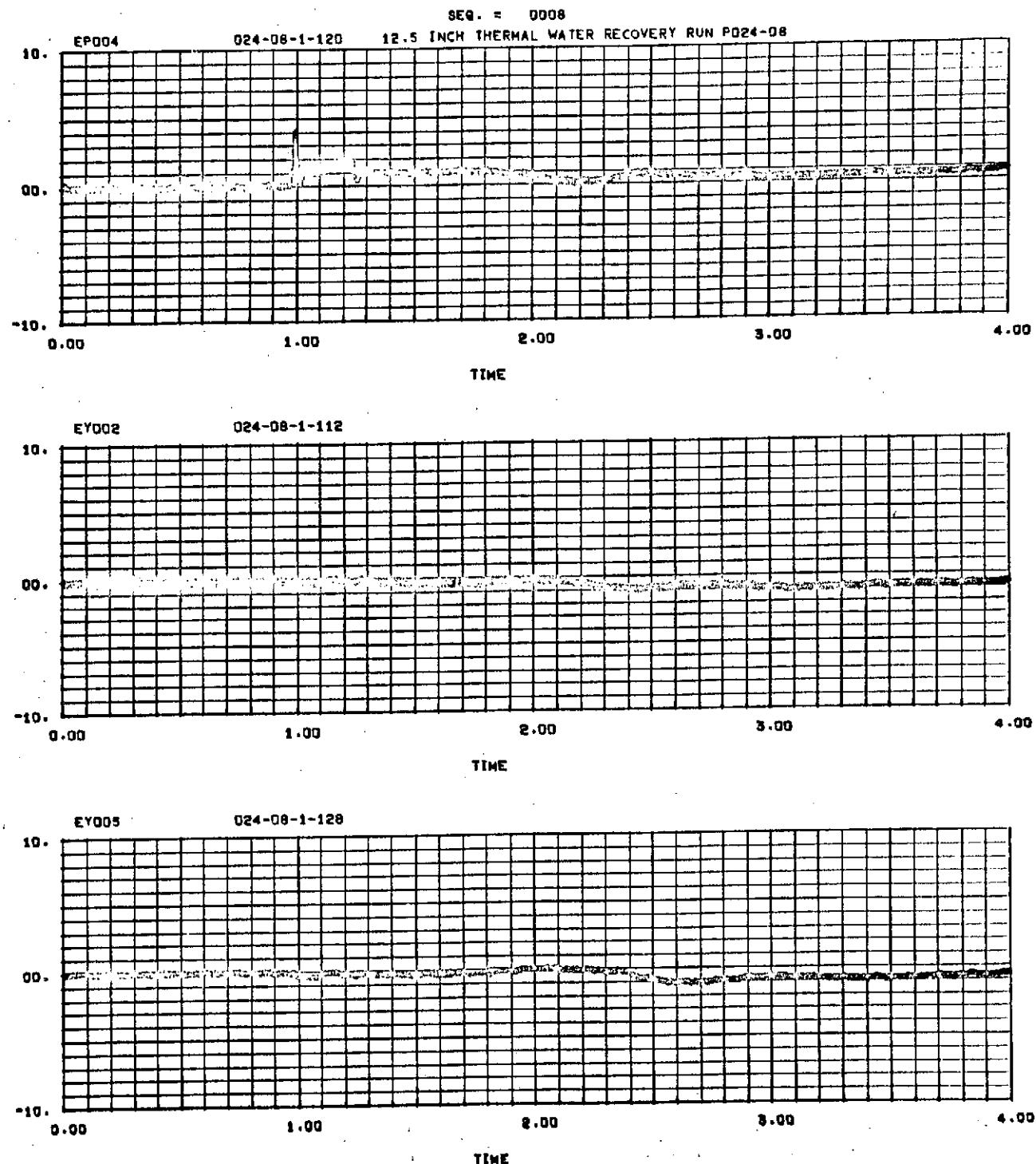




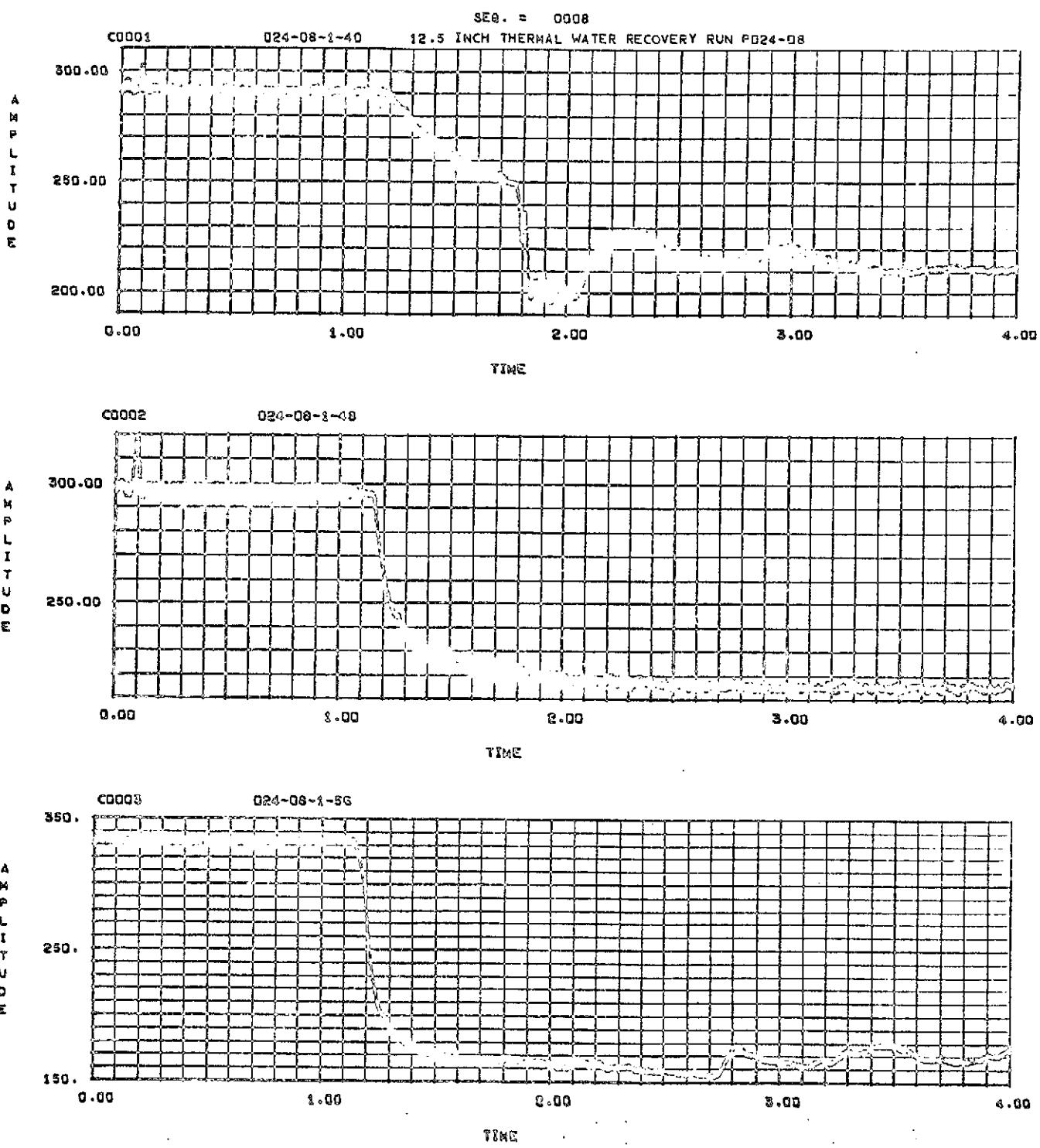


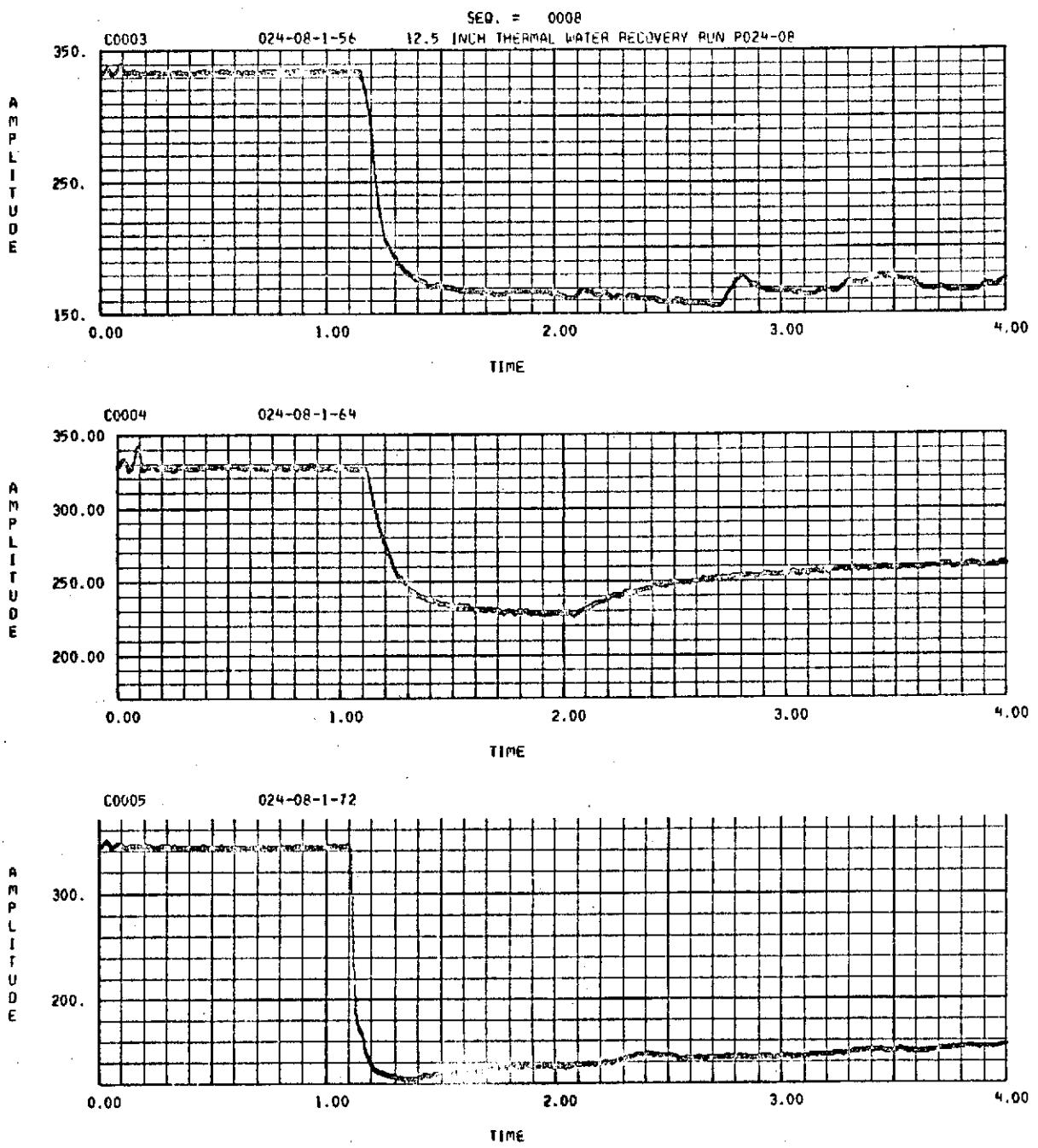
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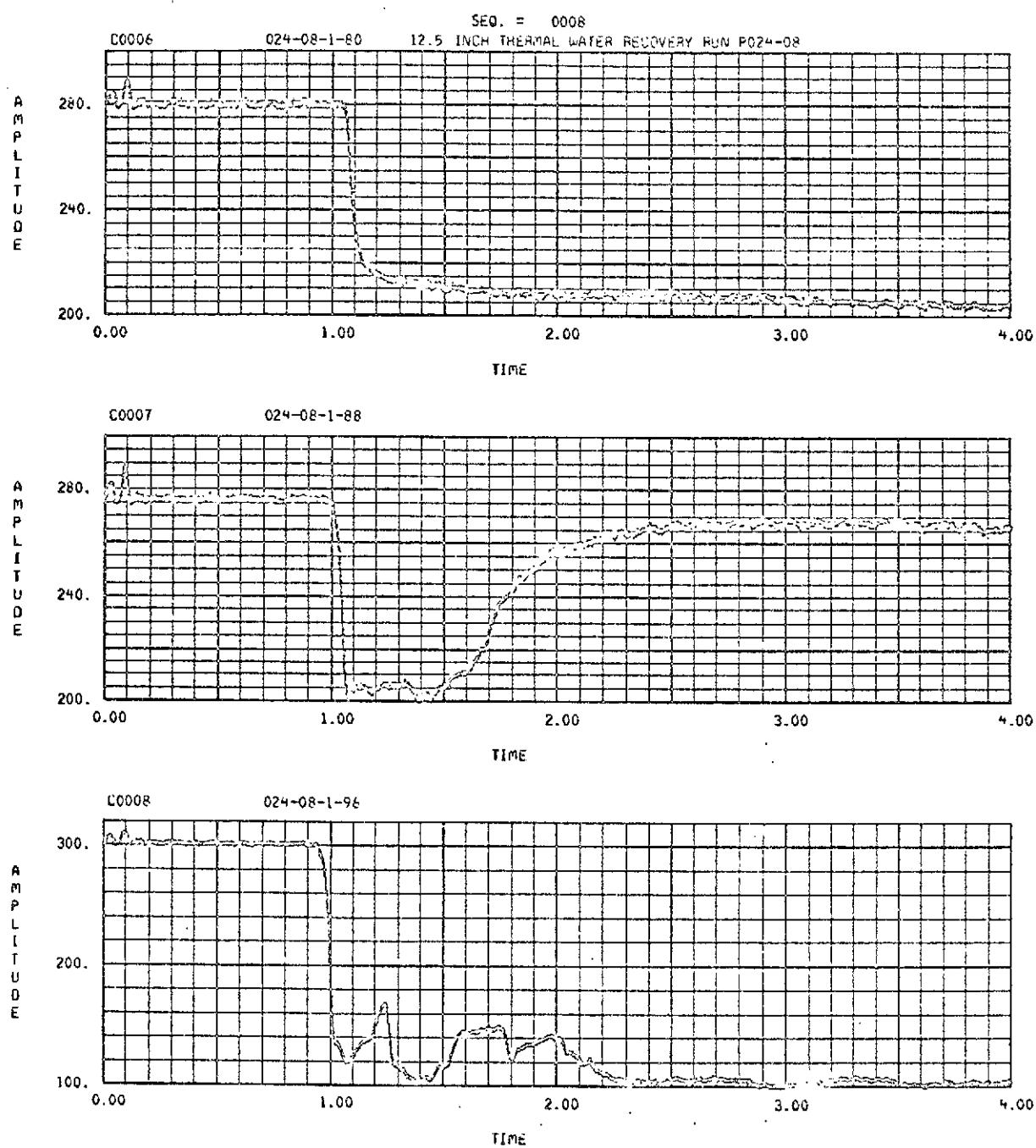


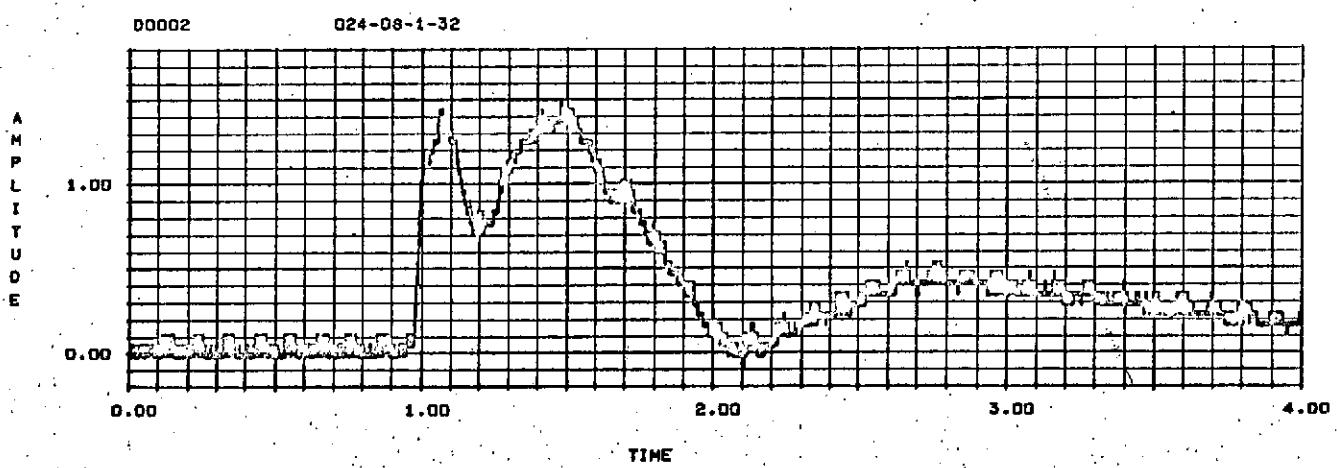
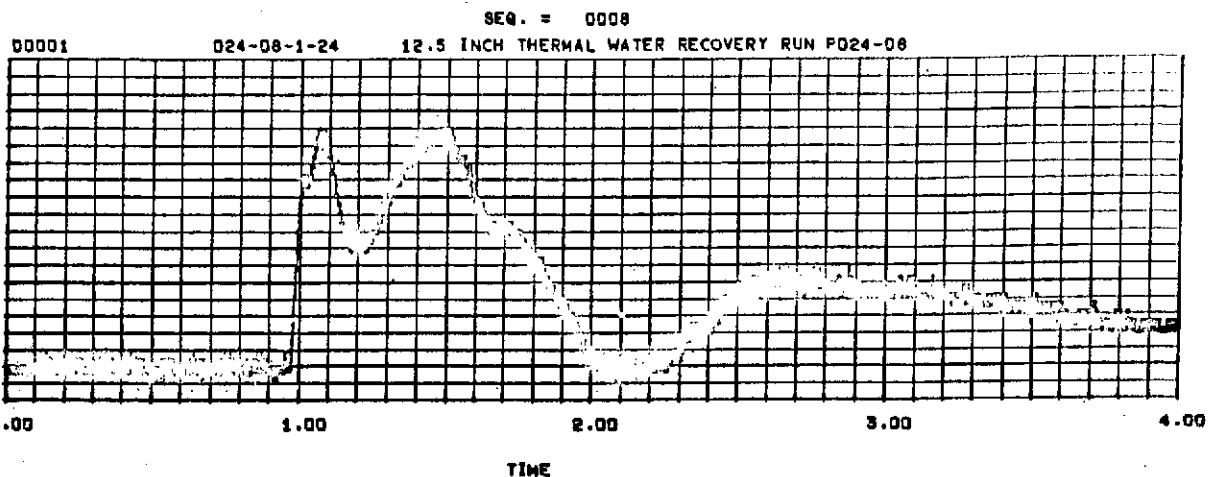
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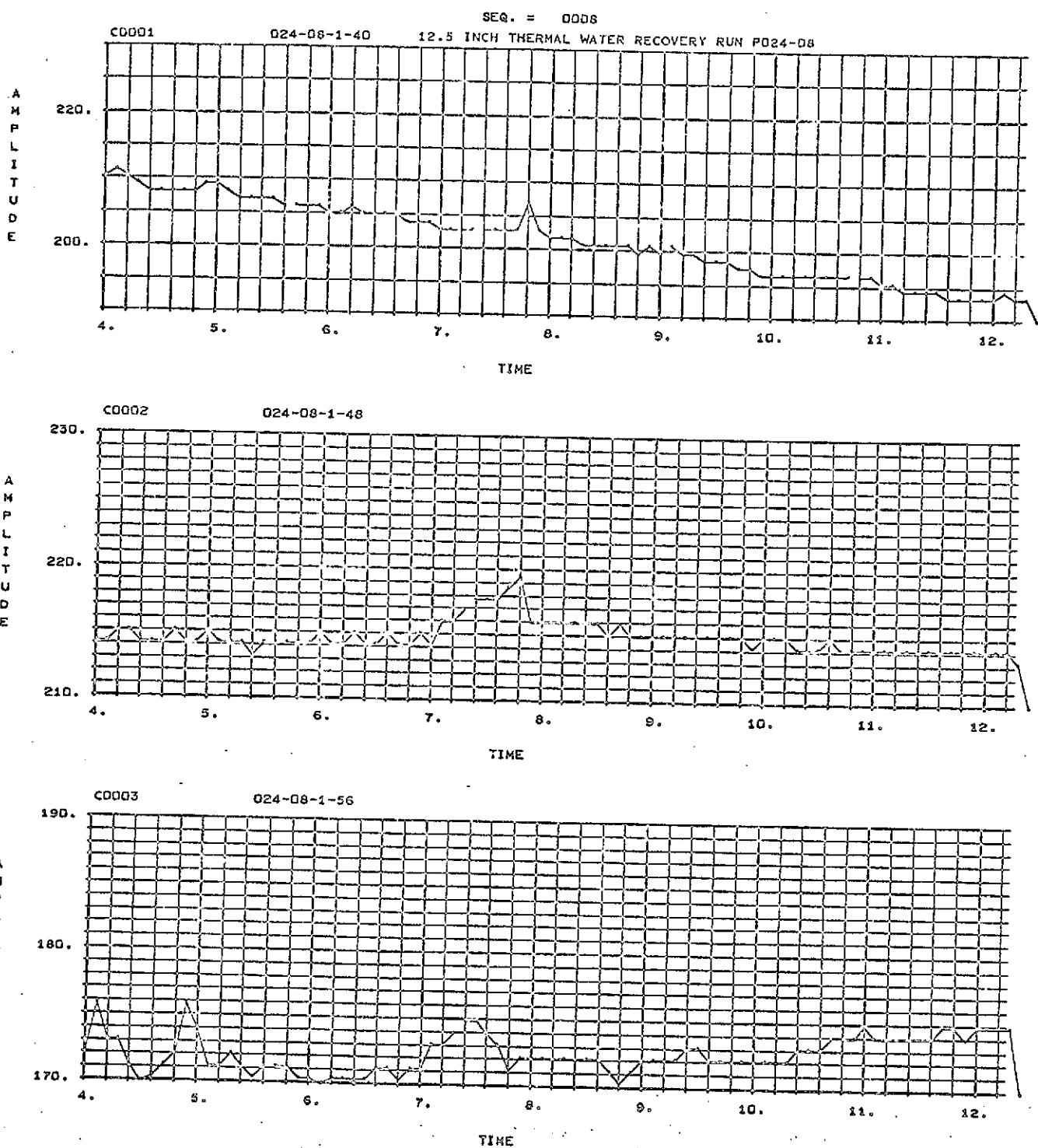


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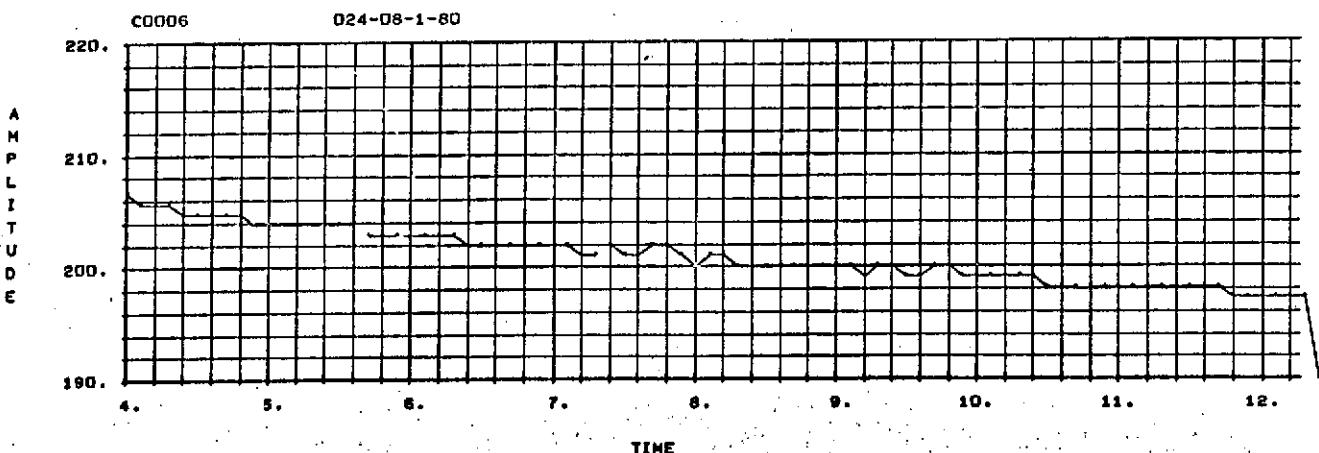
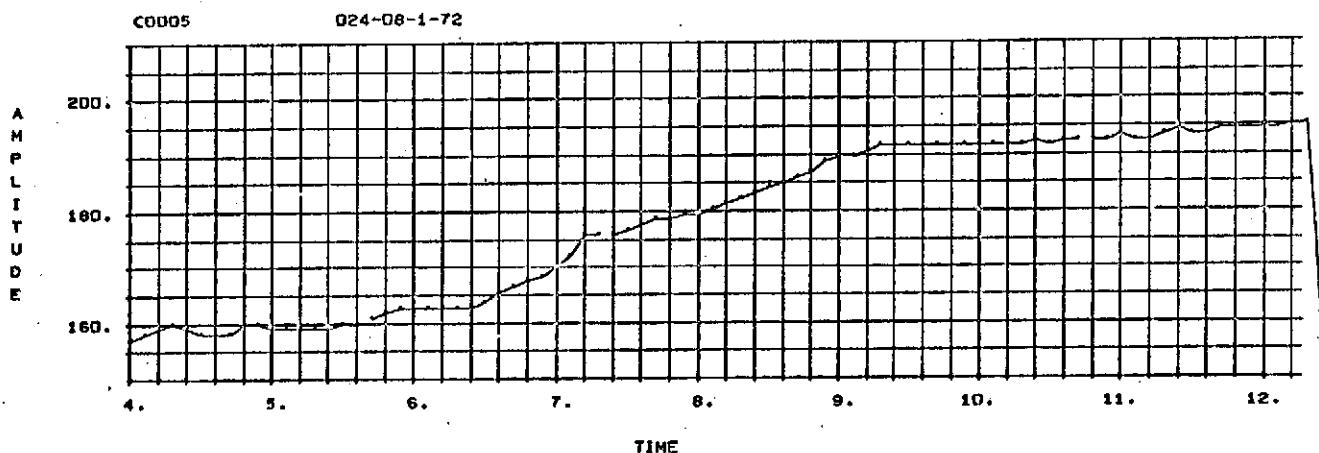
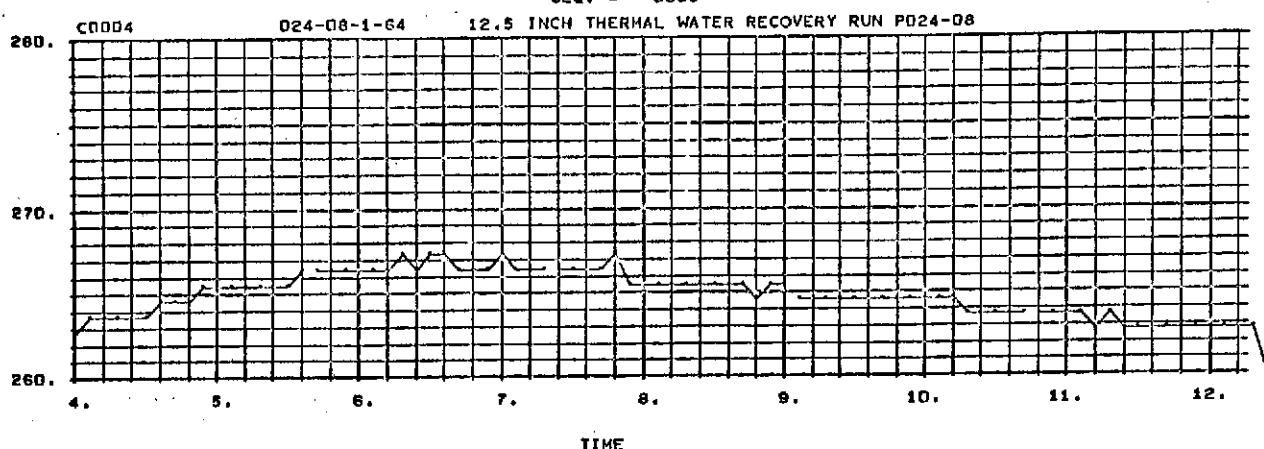




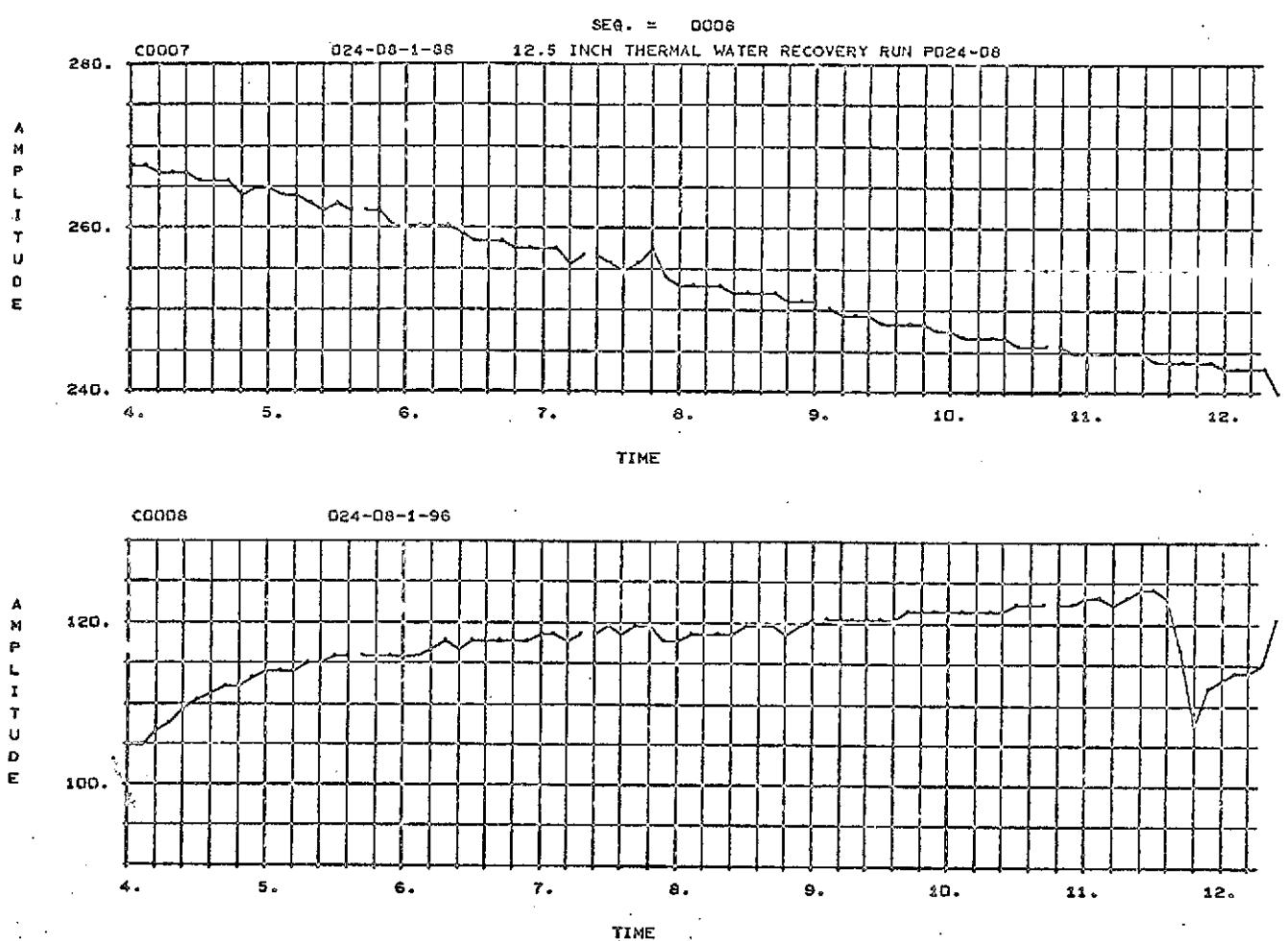
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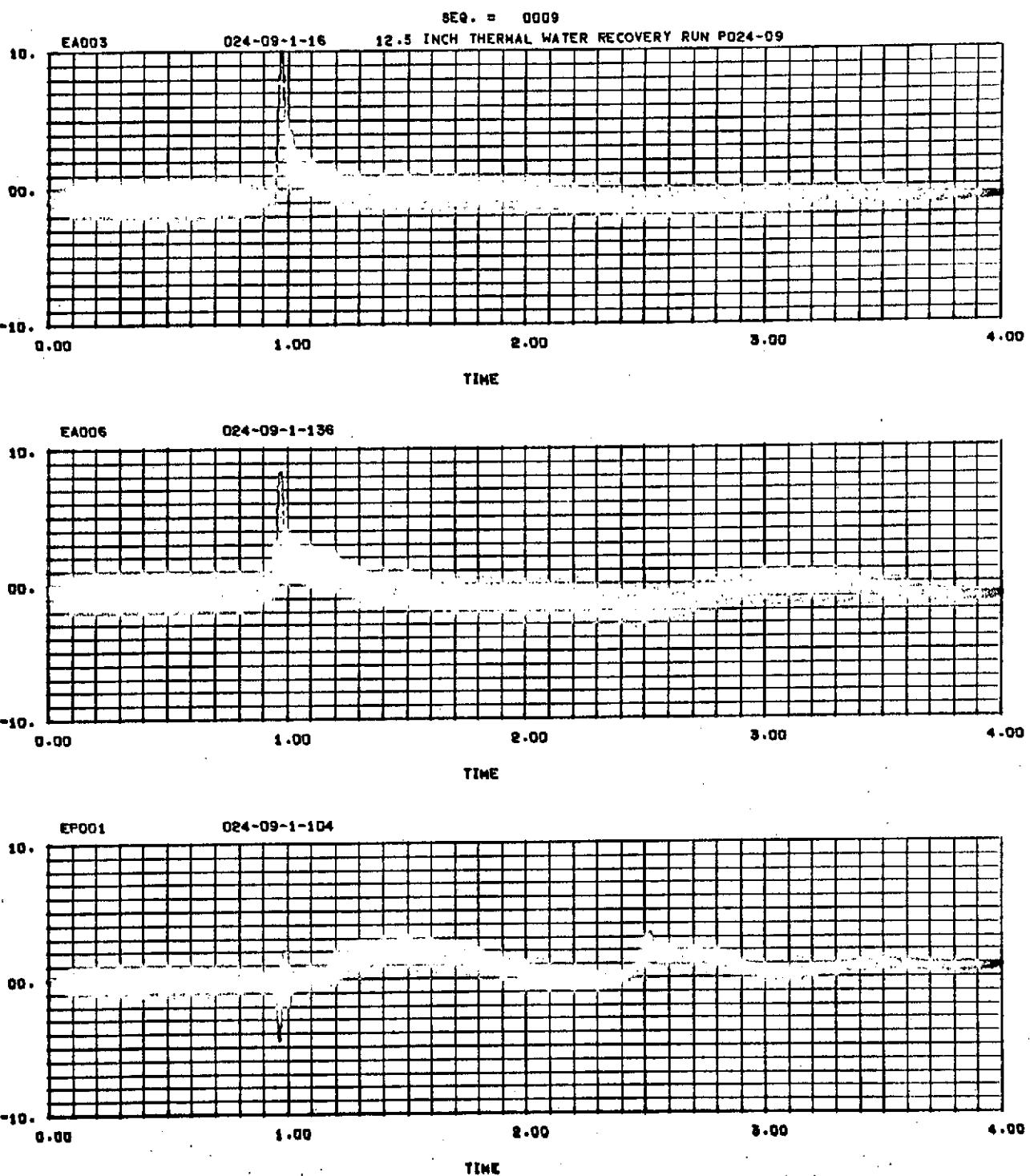


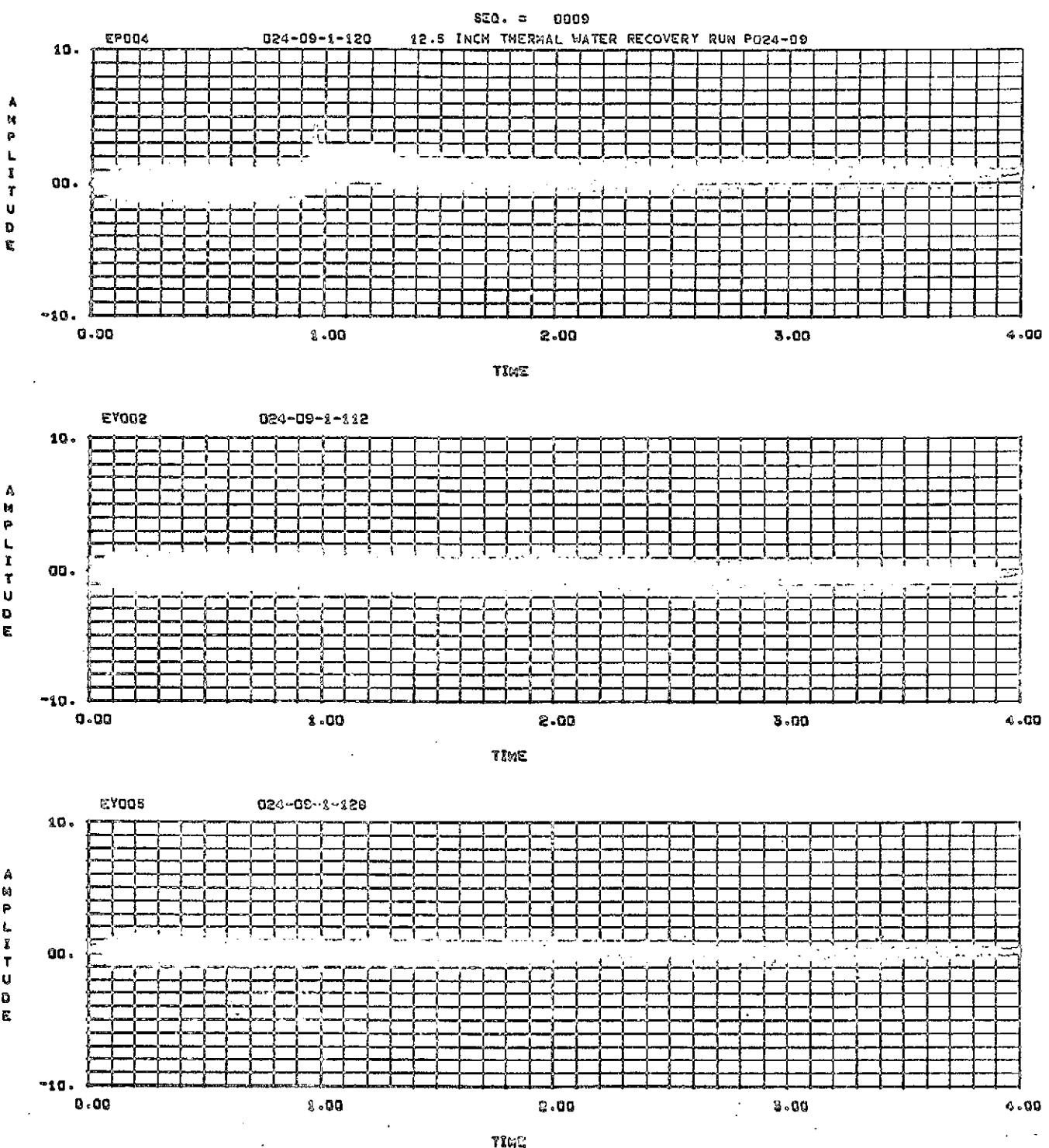
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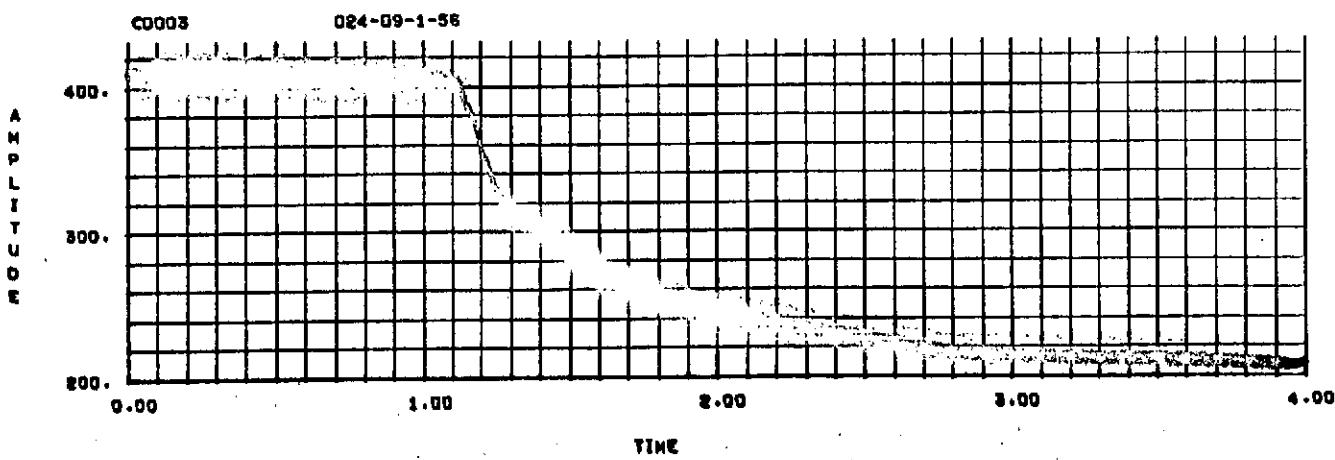
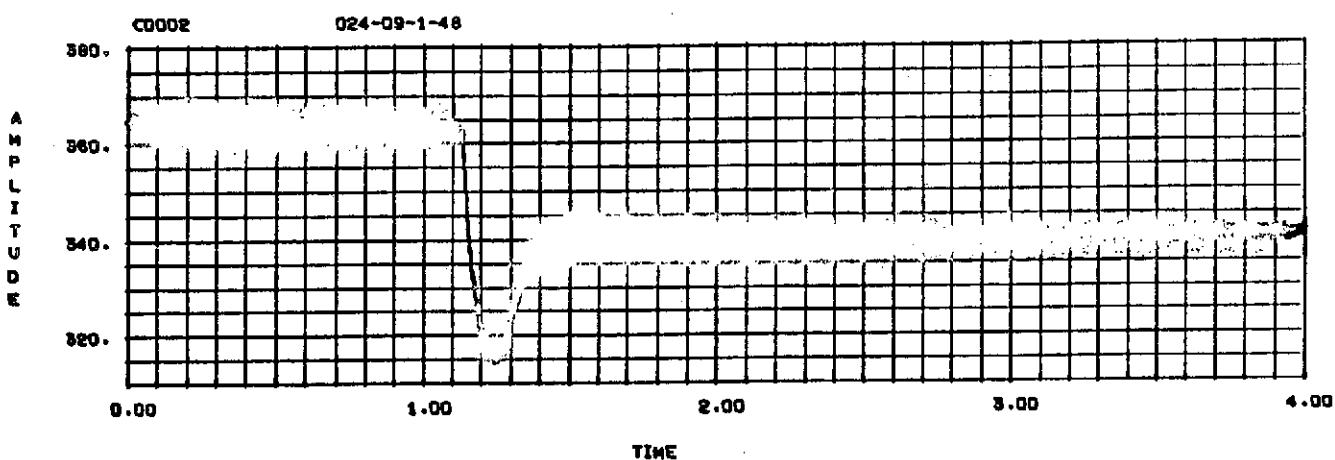
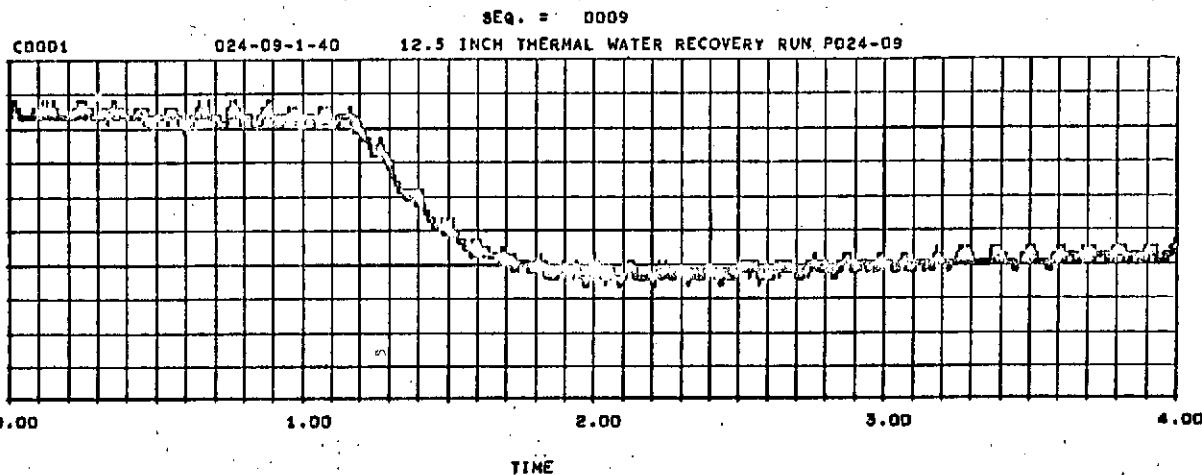


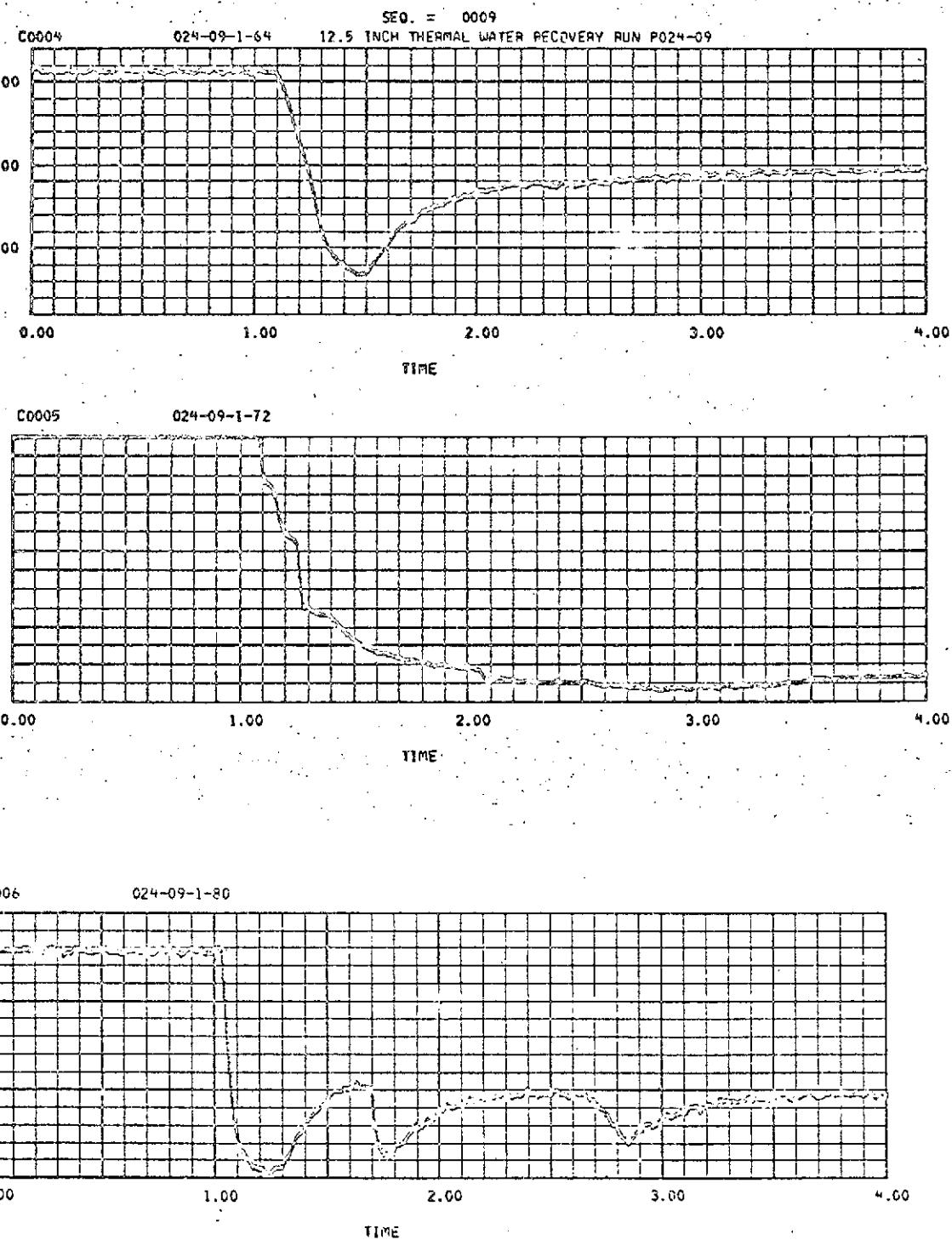
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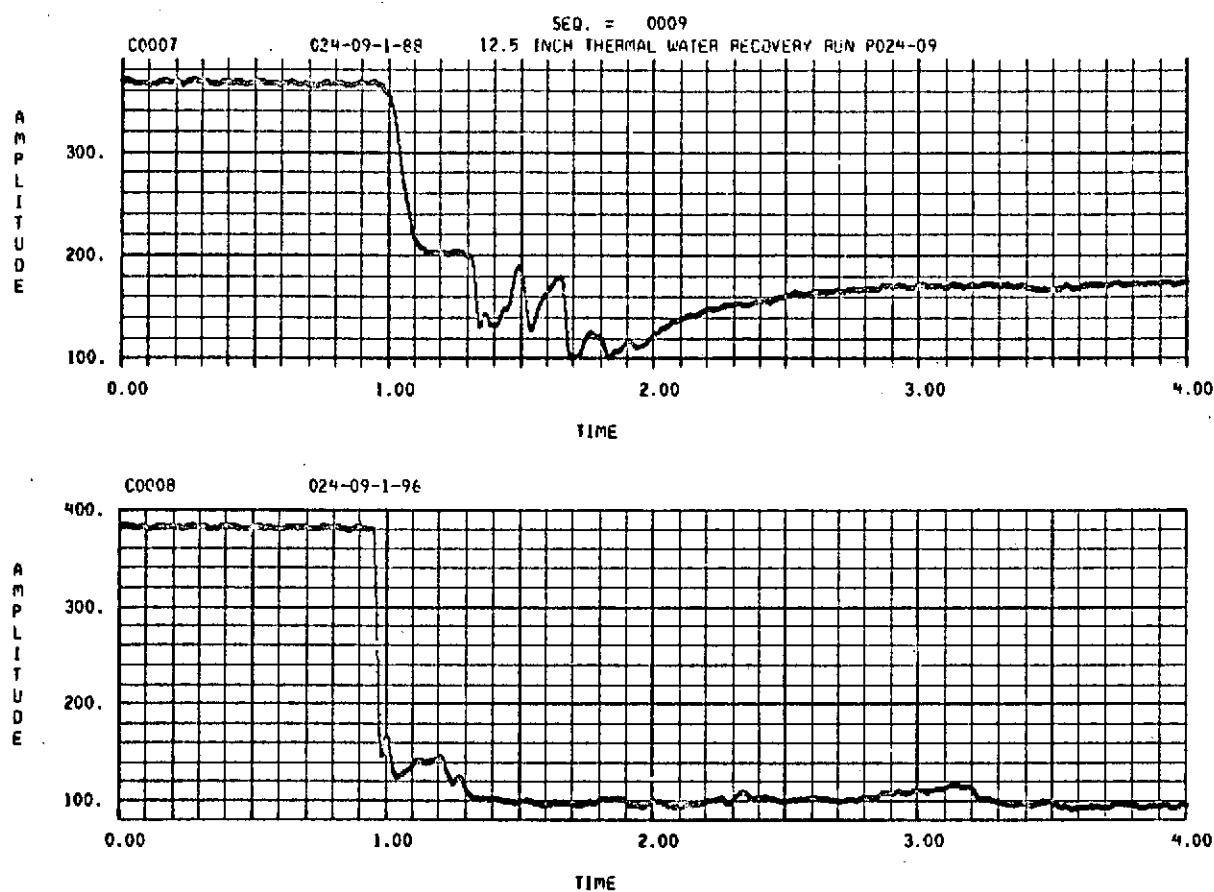






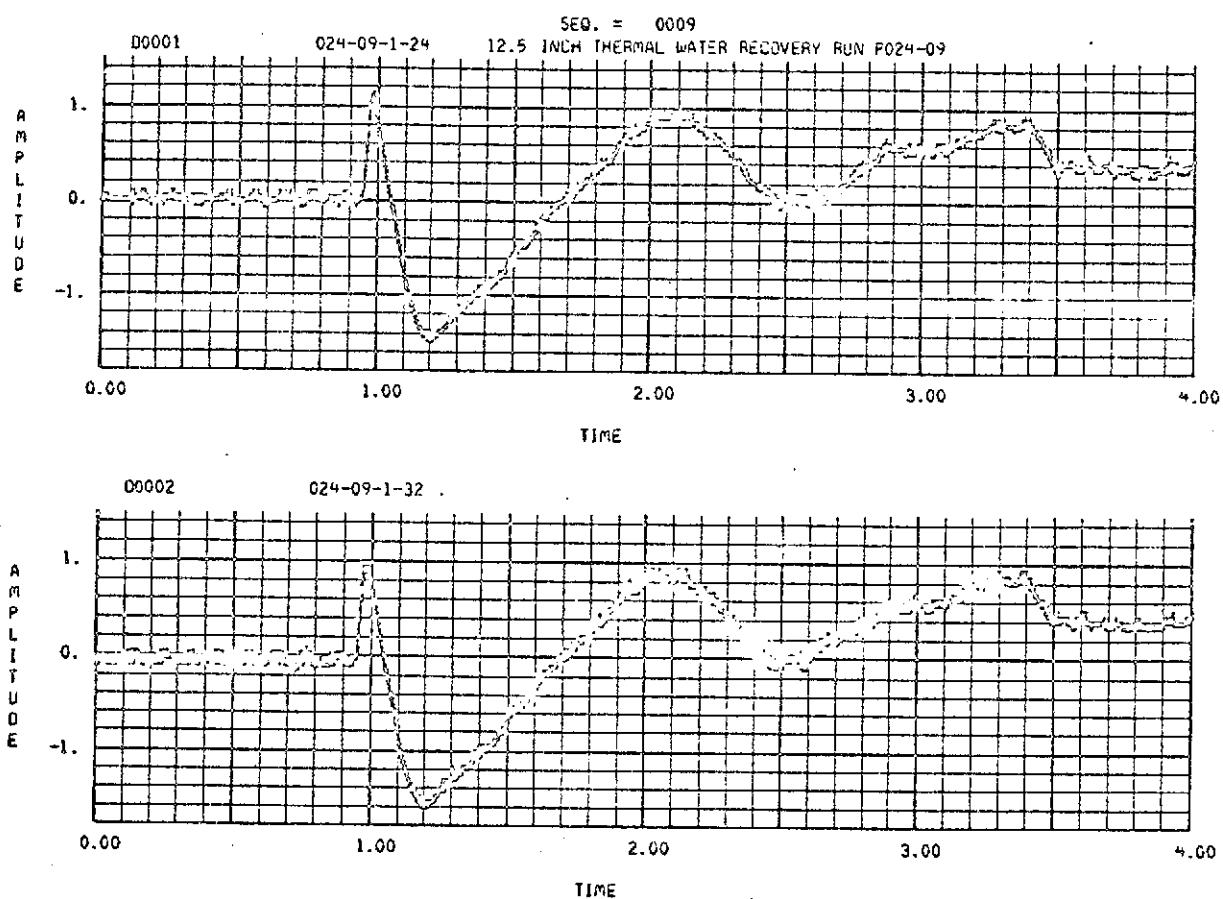


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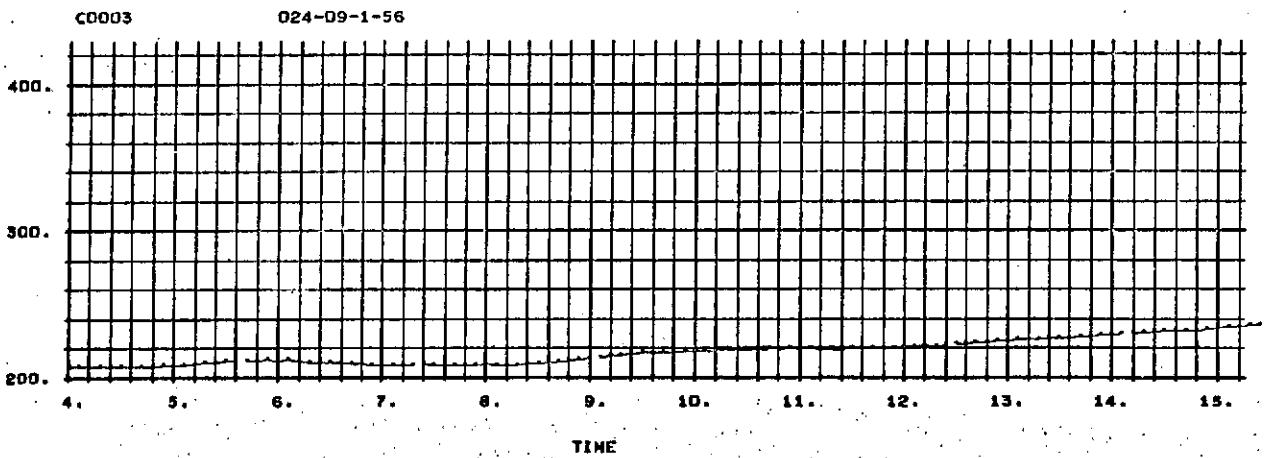
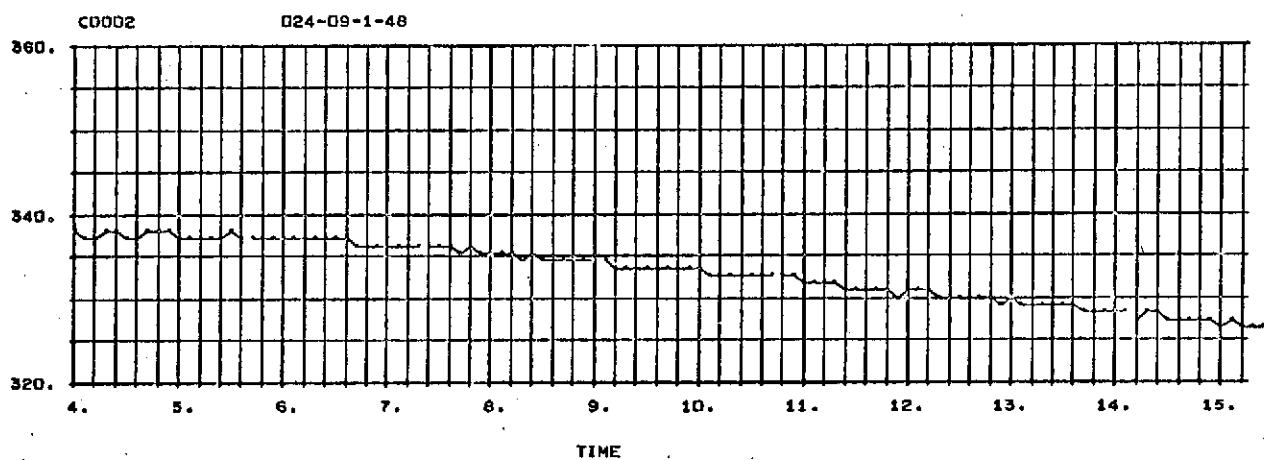
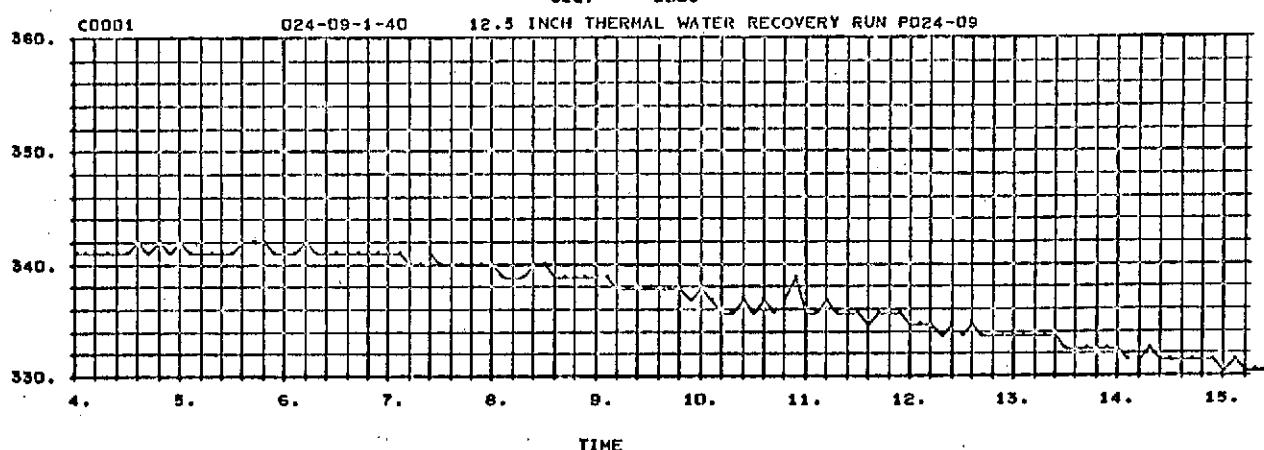


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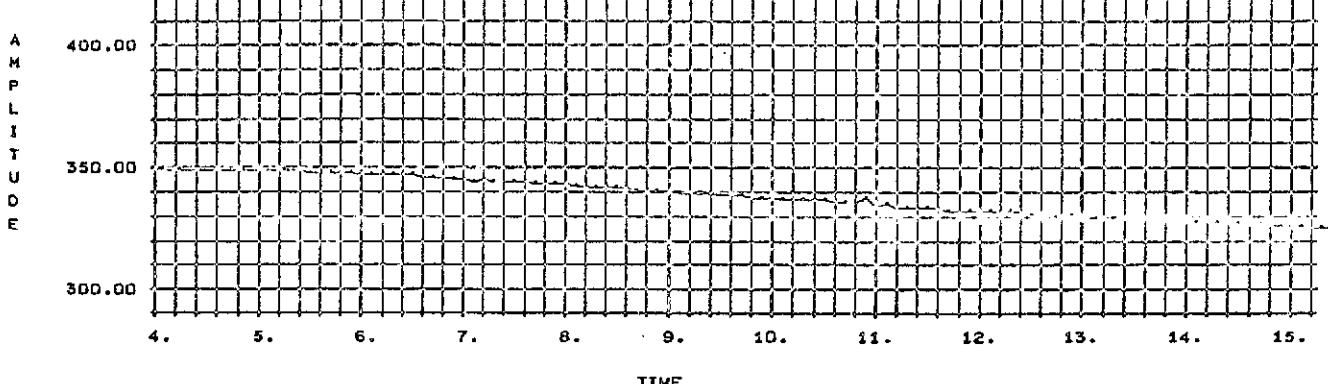
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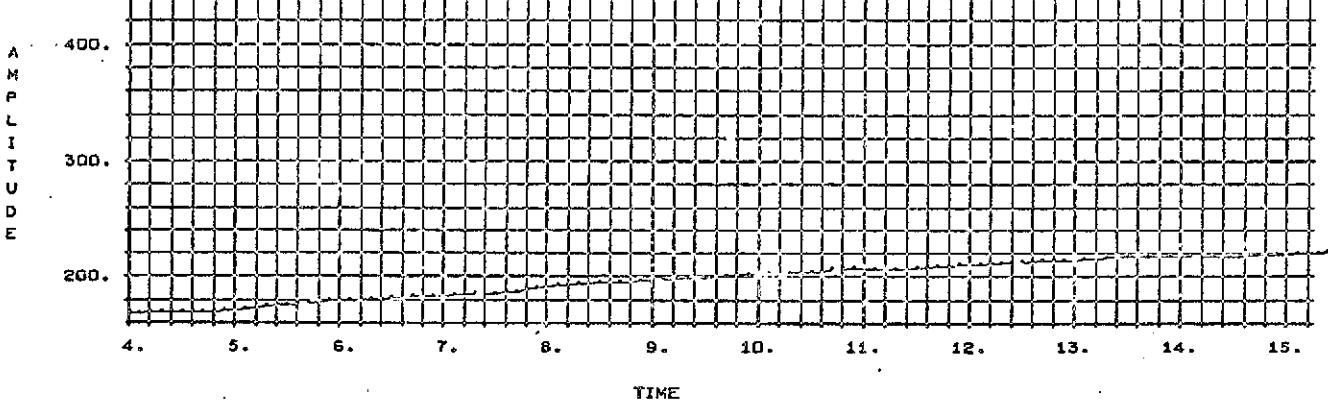
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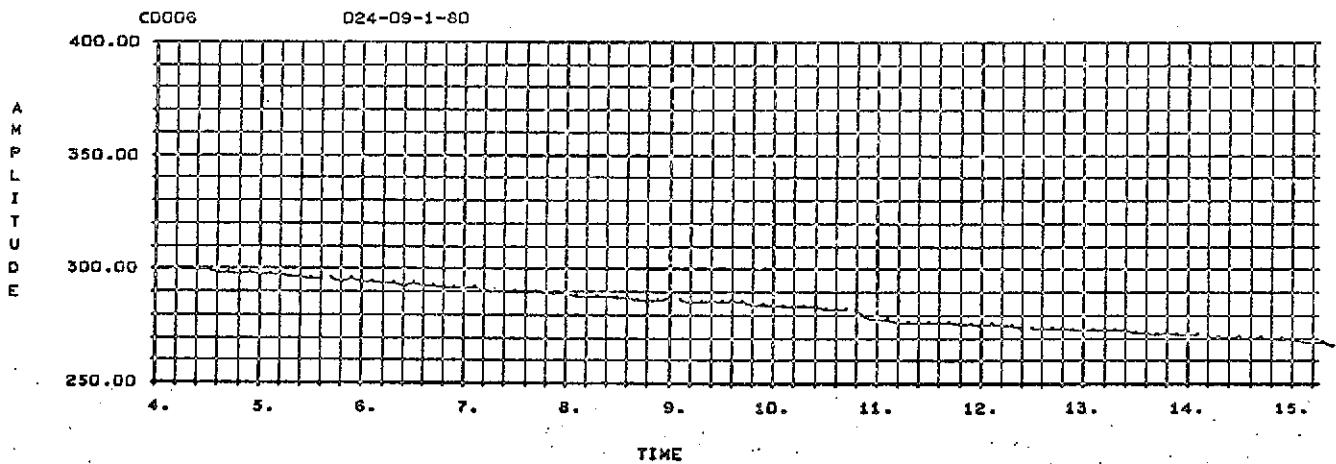
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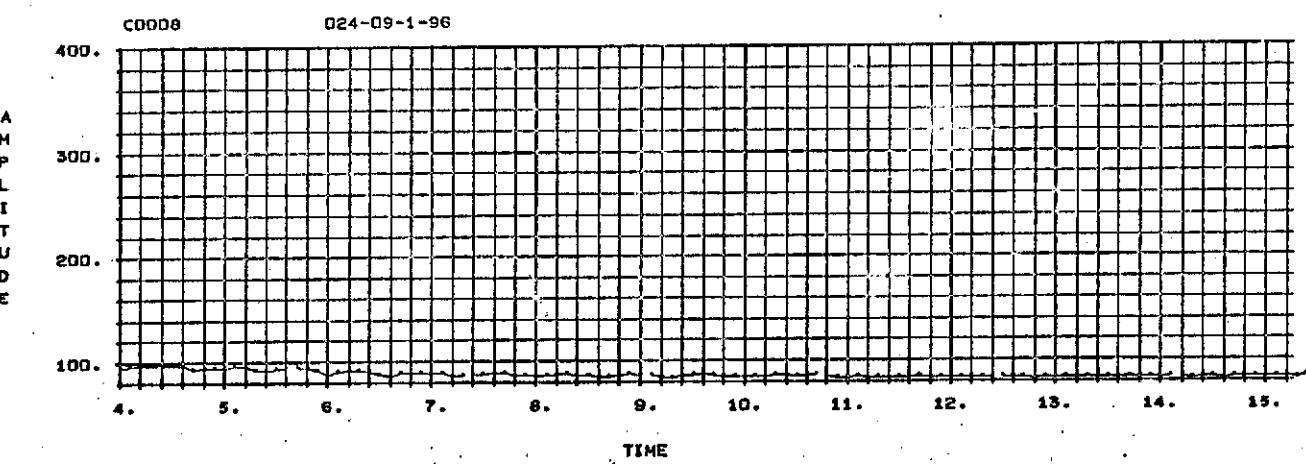
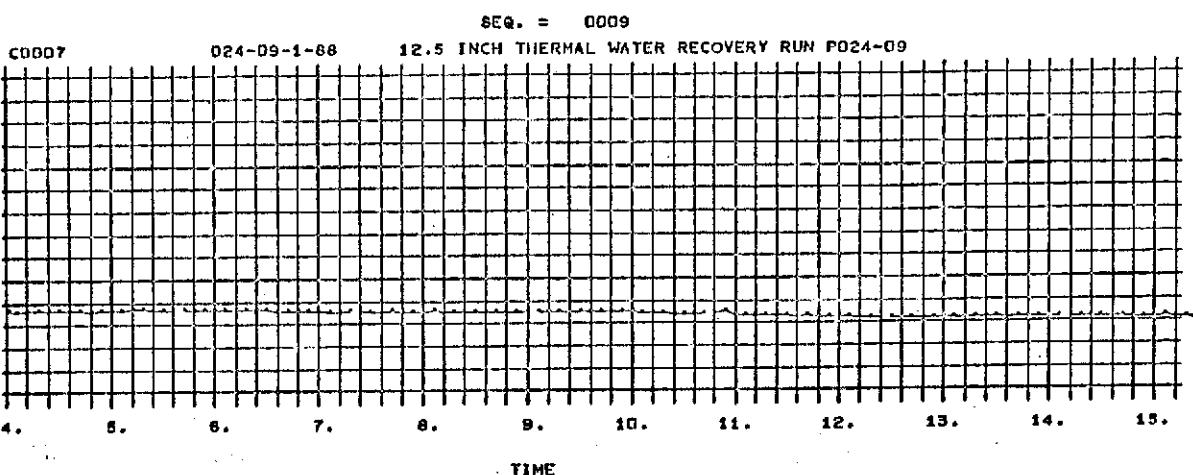


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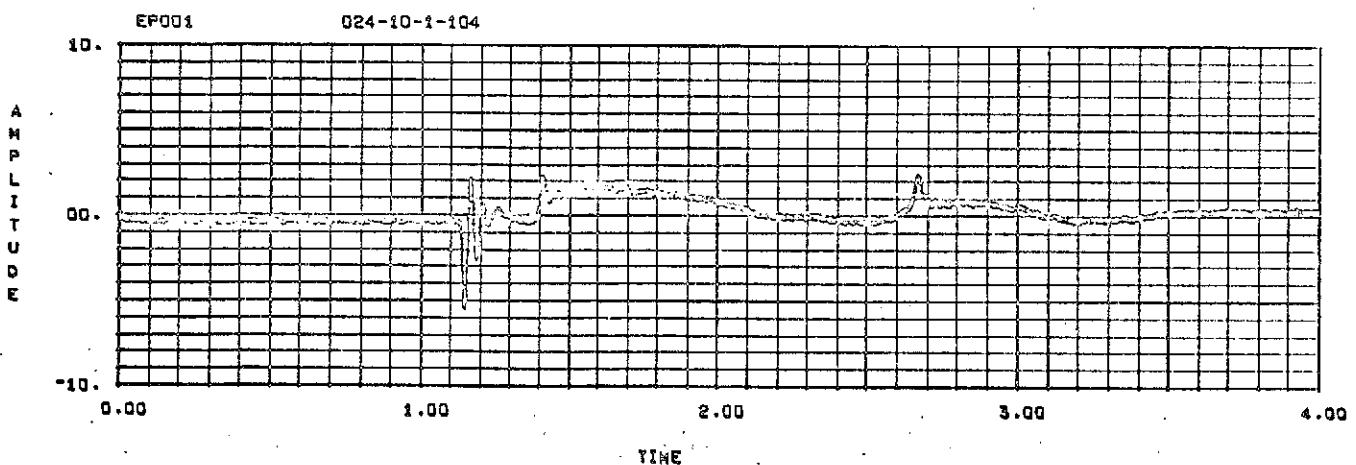
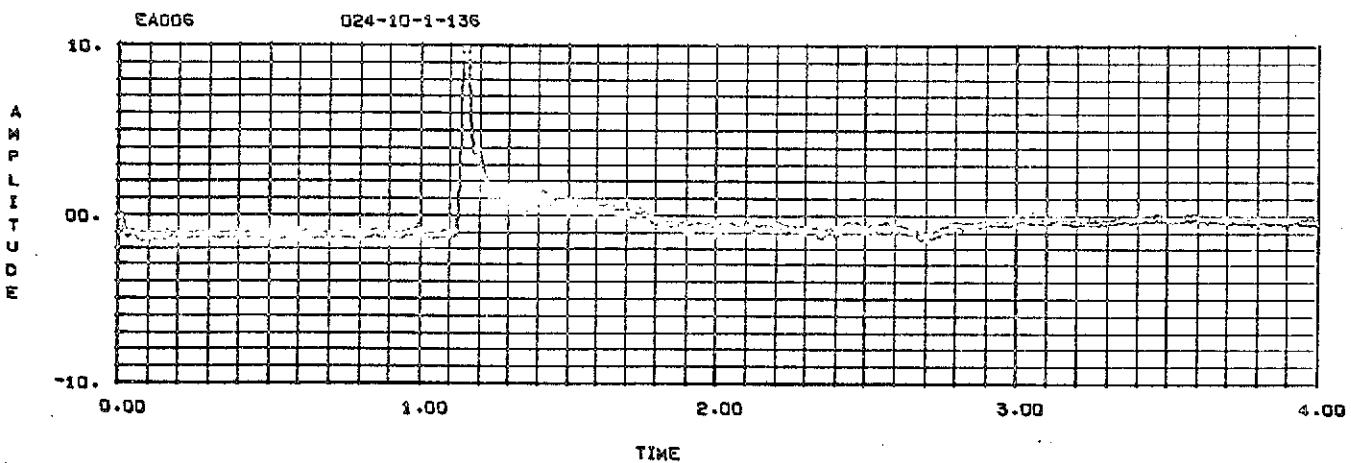
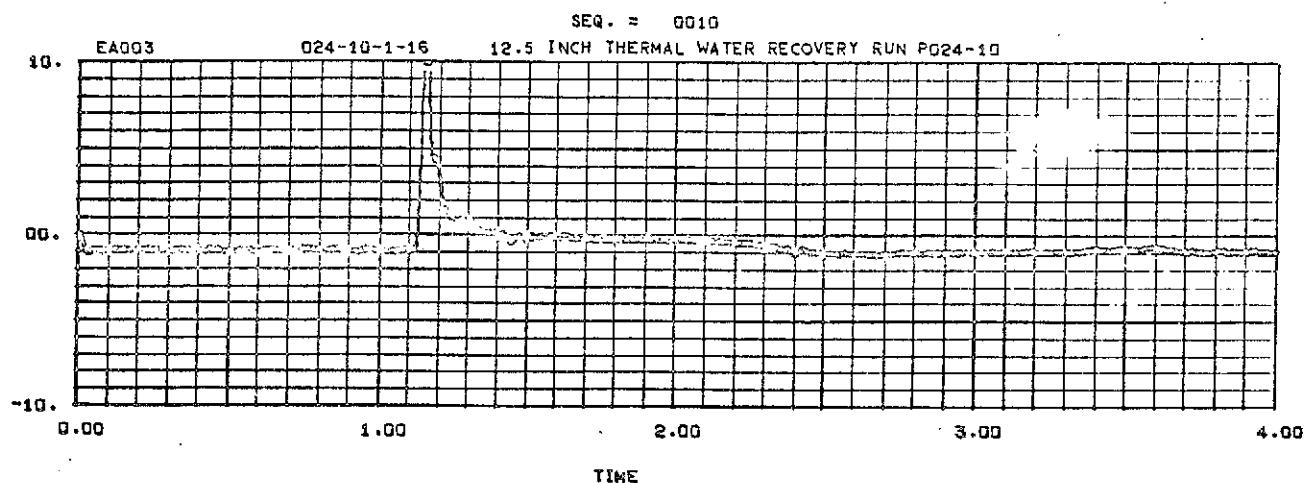


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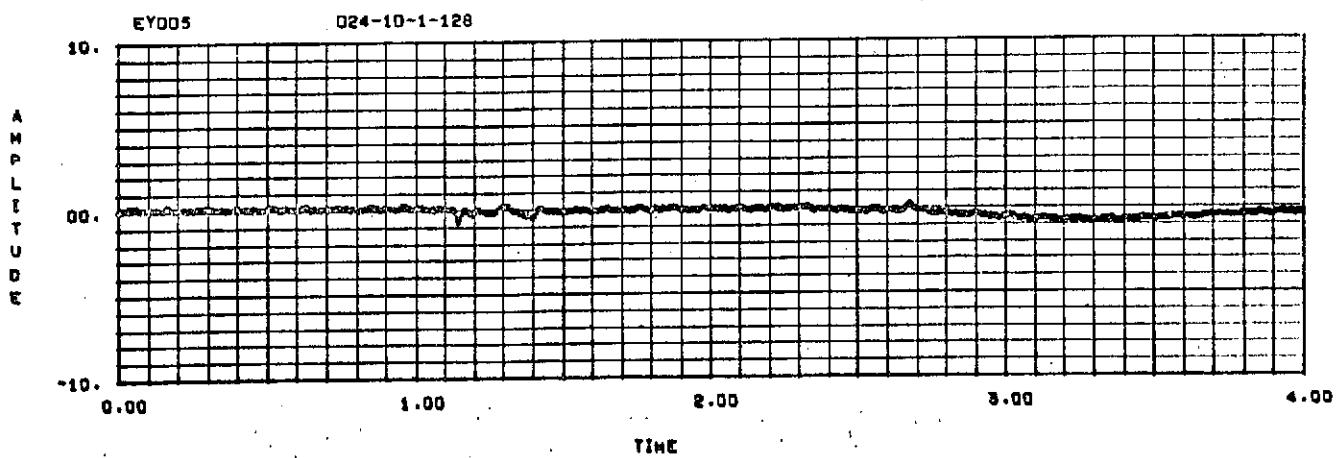
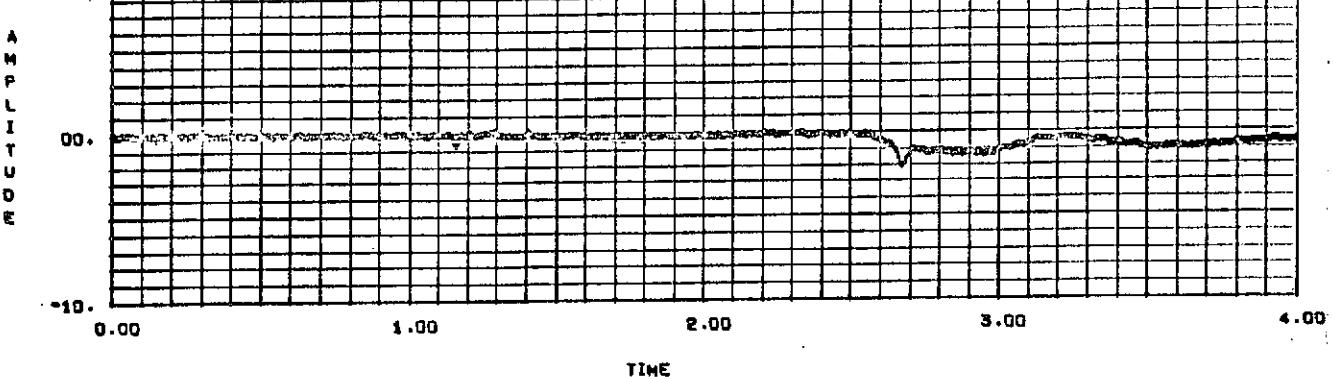
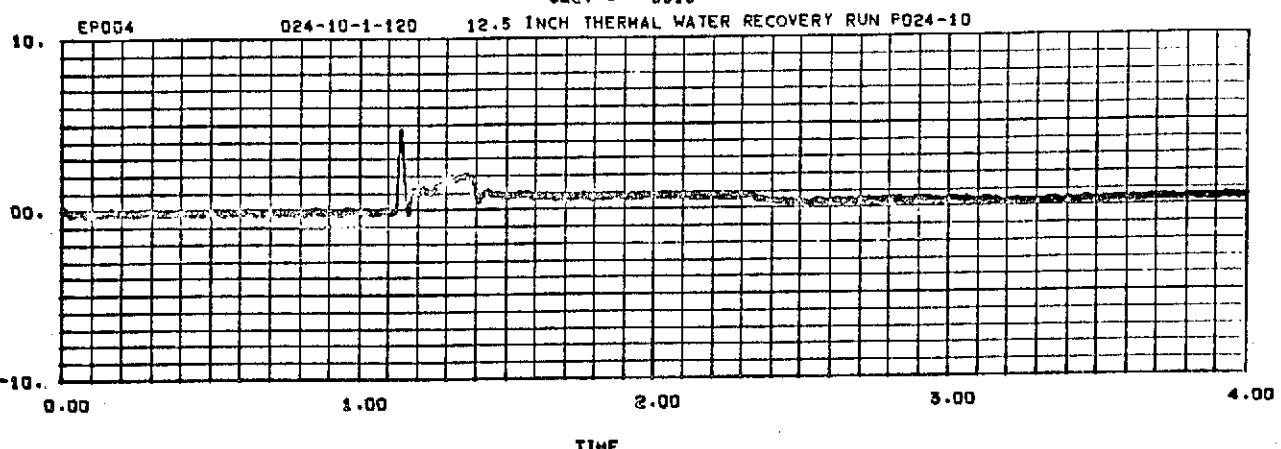


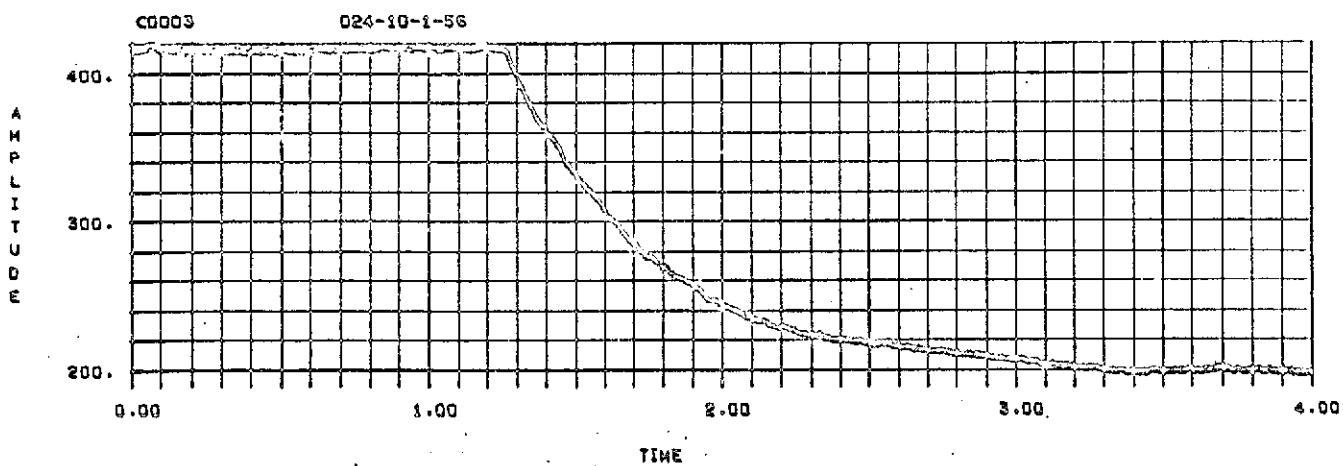
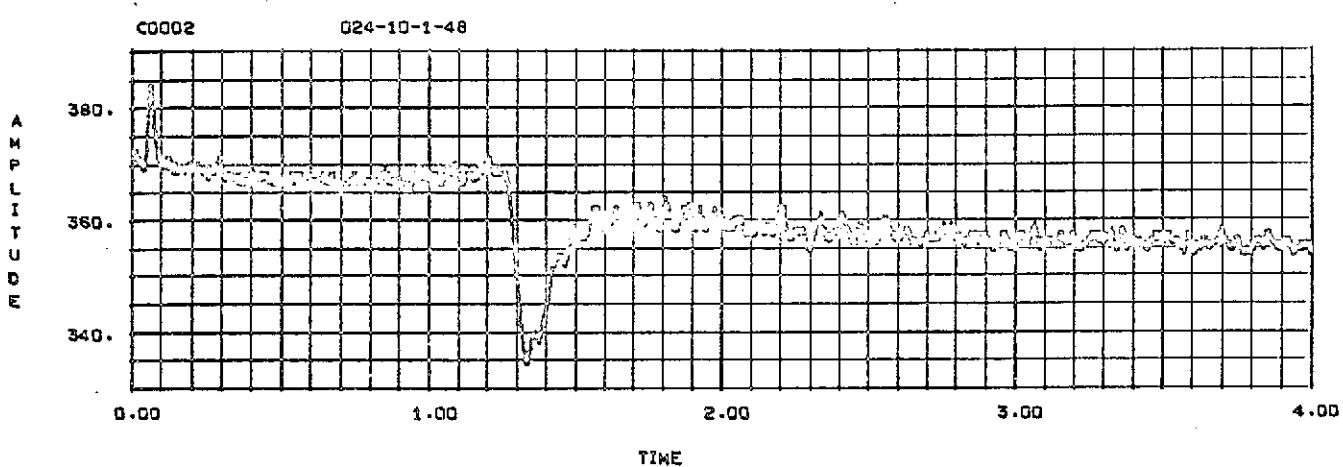
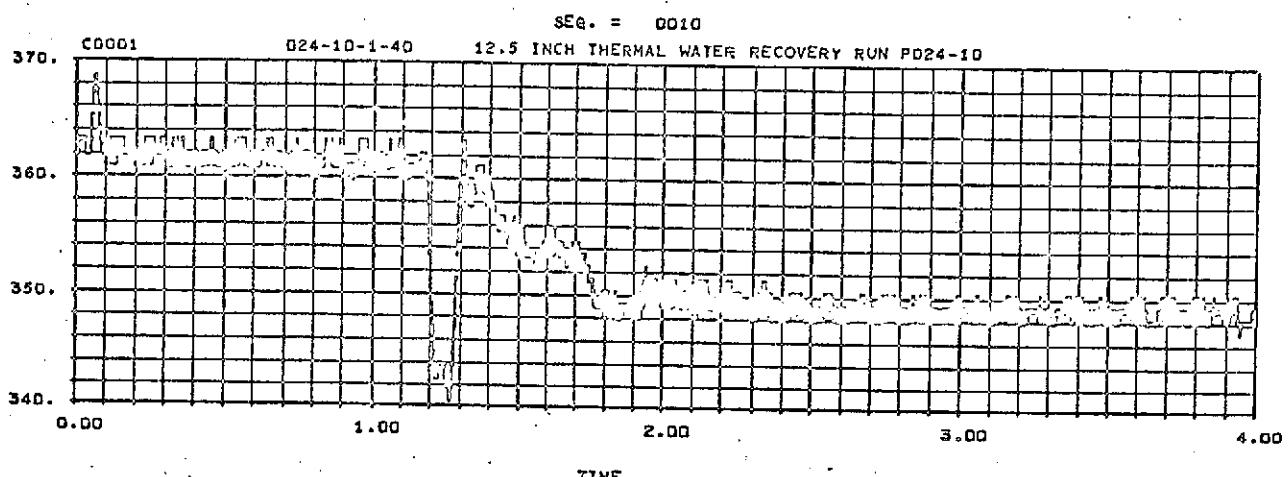


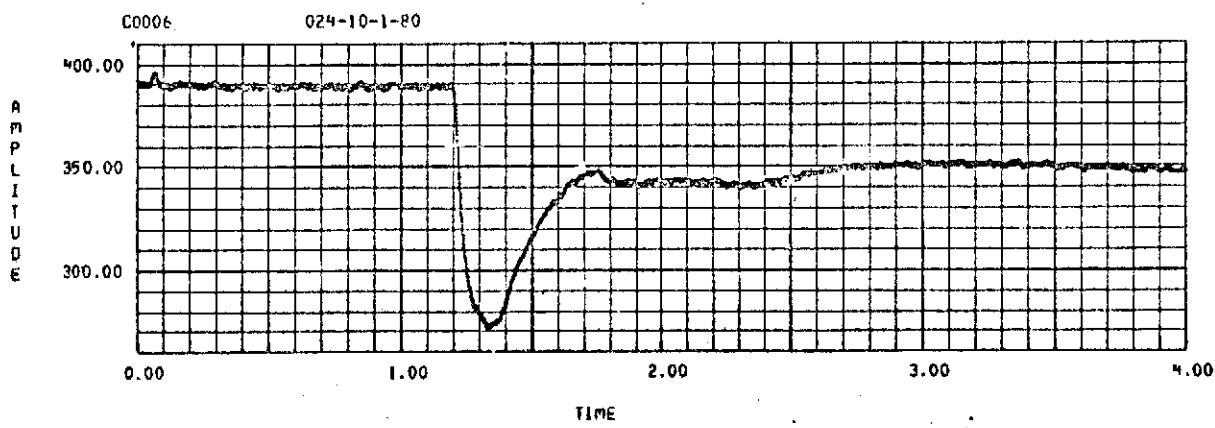
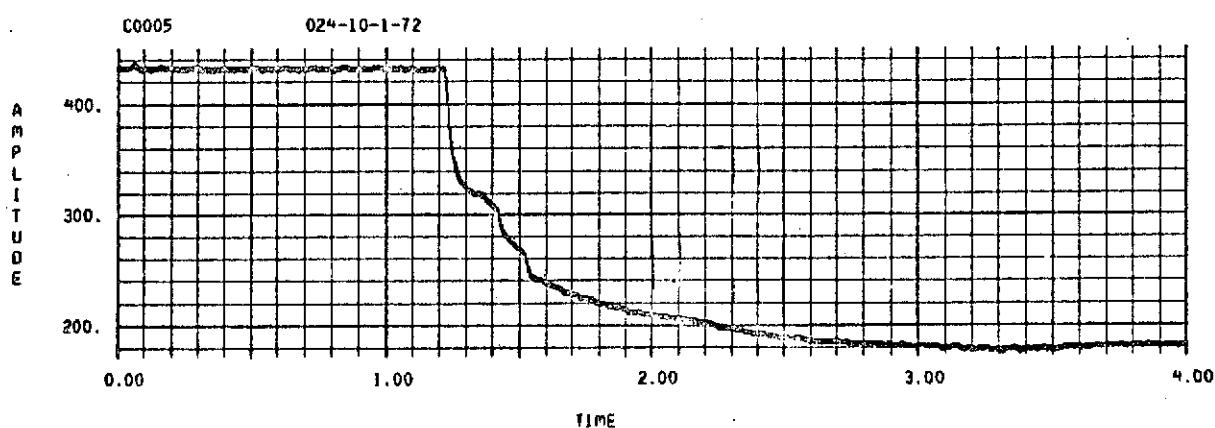
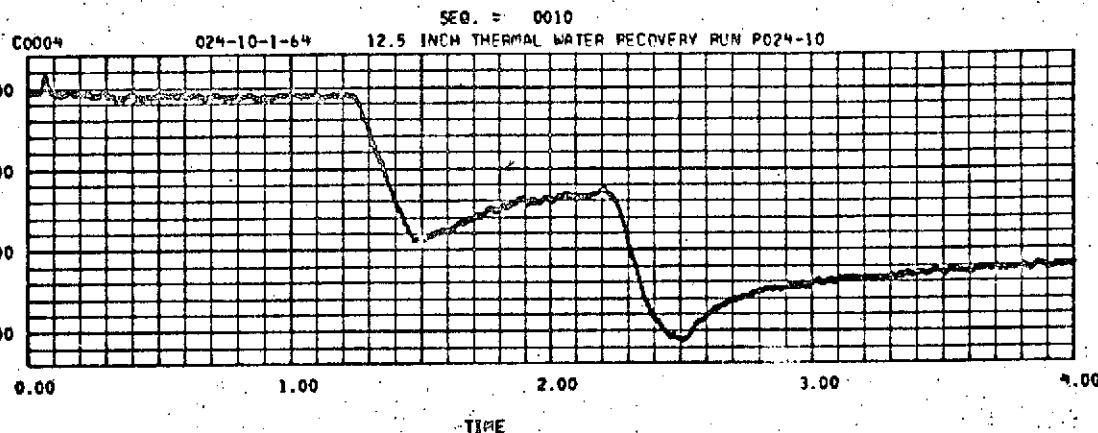
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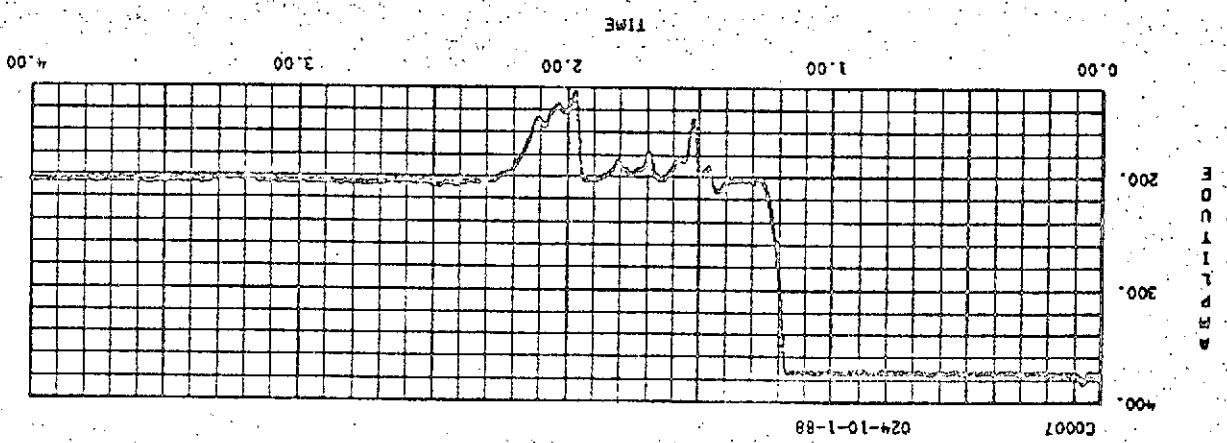
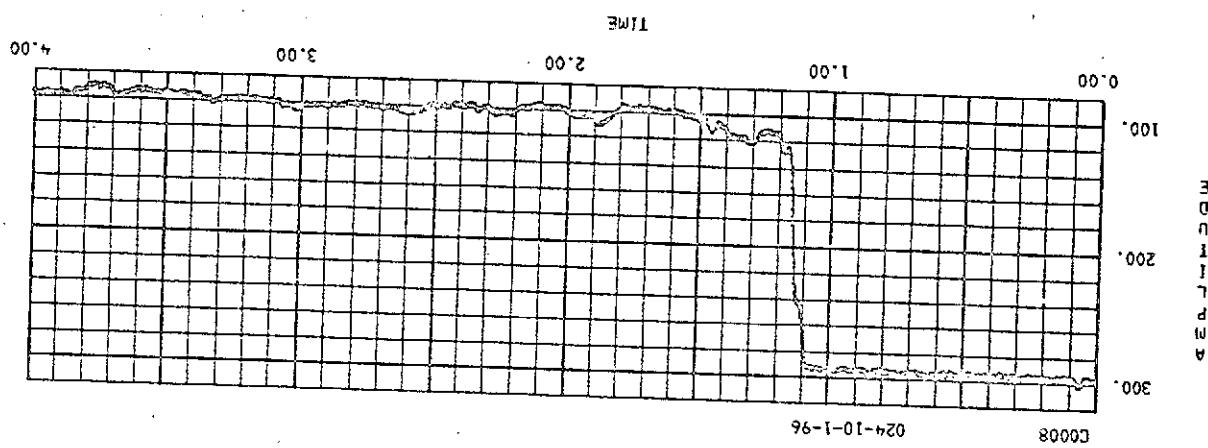
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B-90



SEQ. = 0010

00001

024-10-1-24

12.5 INCH THERMAL WATER RECOVERY RUN P024-10

AMPLITUDE

0.
-2.

0.00

1.00

2.00

3.00

4.00

TIME

00002

024-10-1-32

AMPLITUDE

0.
-2.

0.00

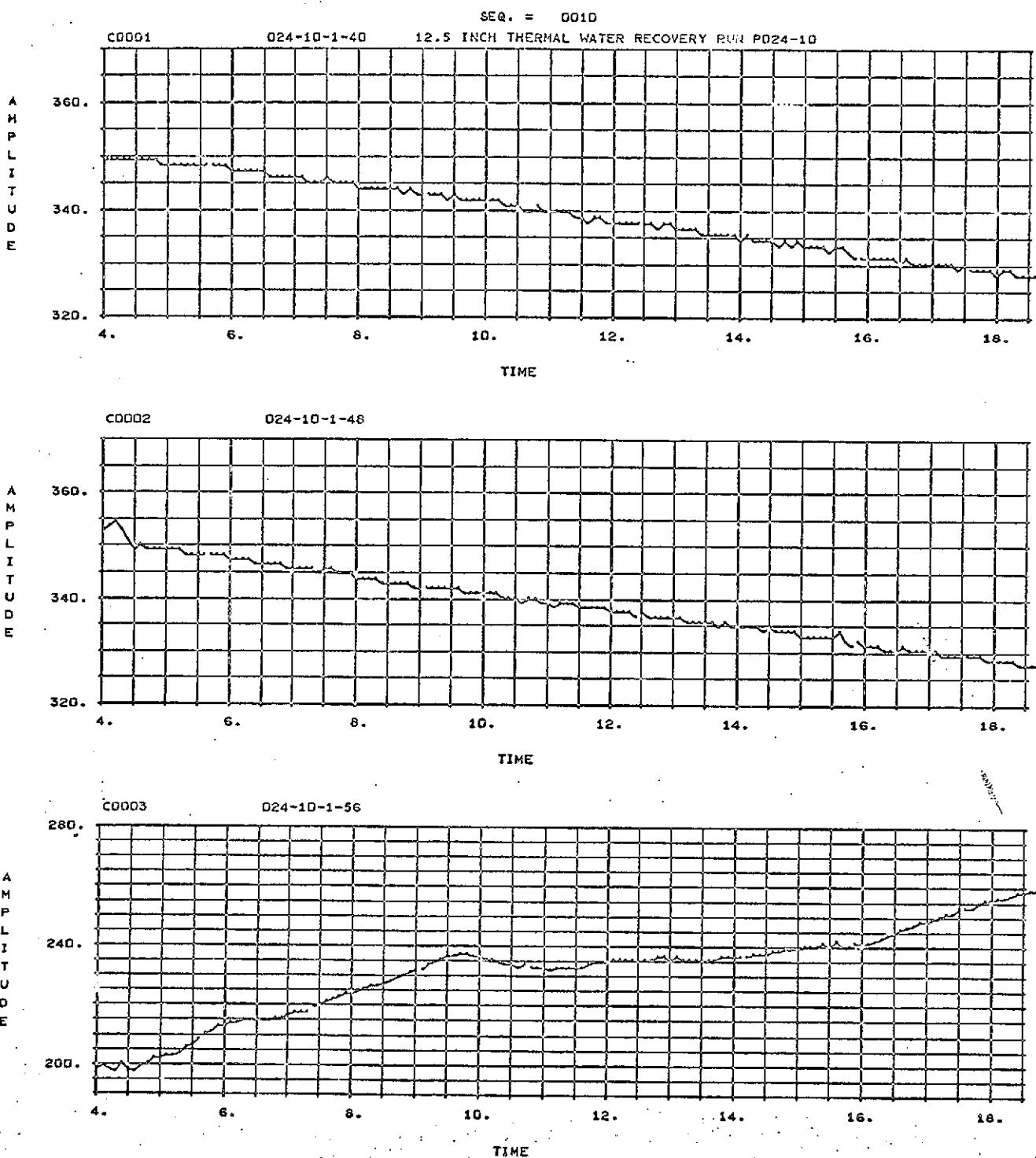
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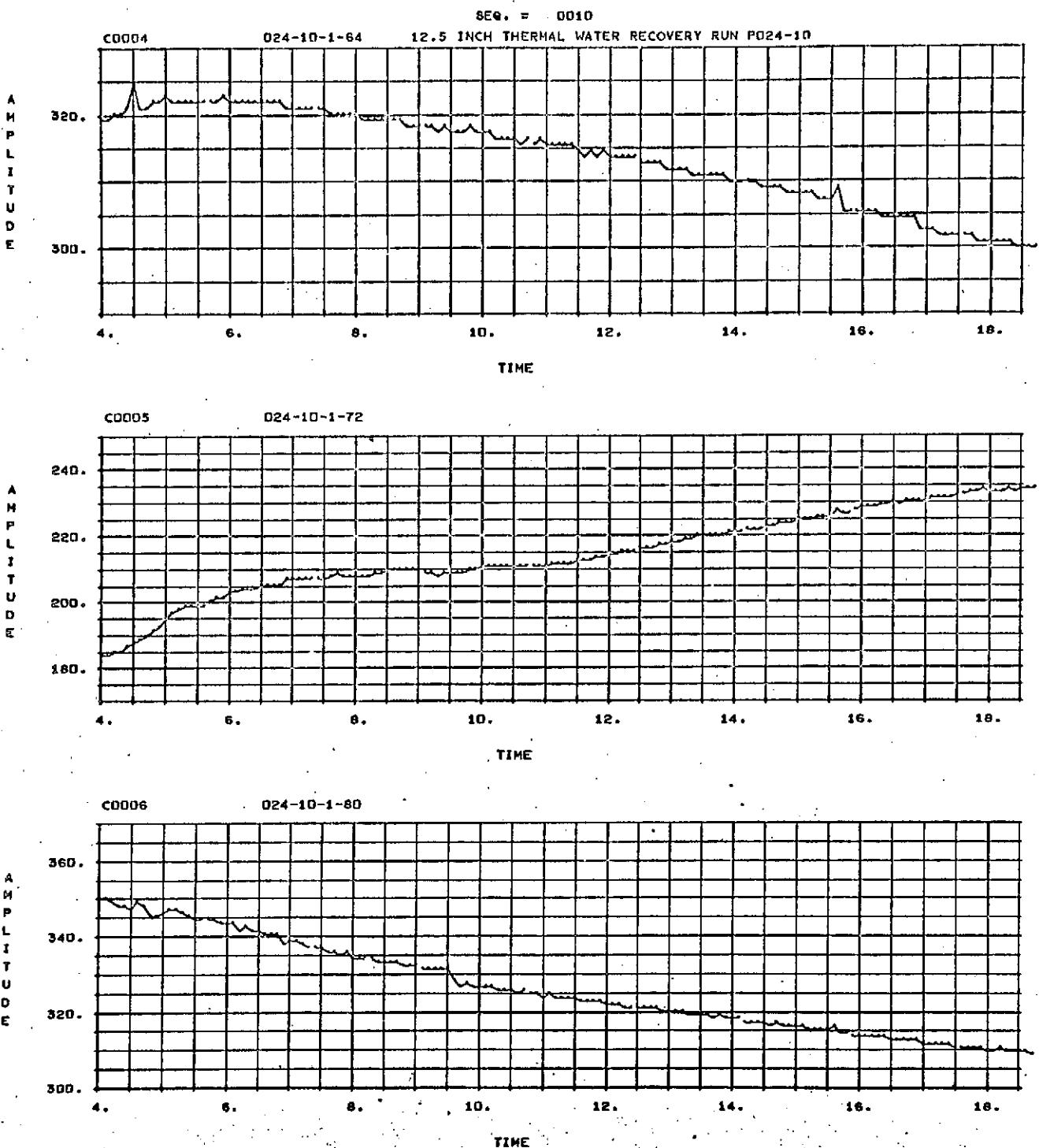
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3.00

4.00

TIME

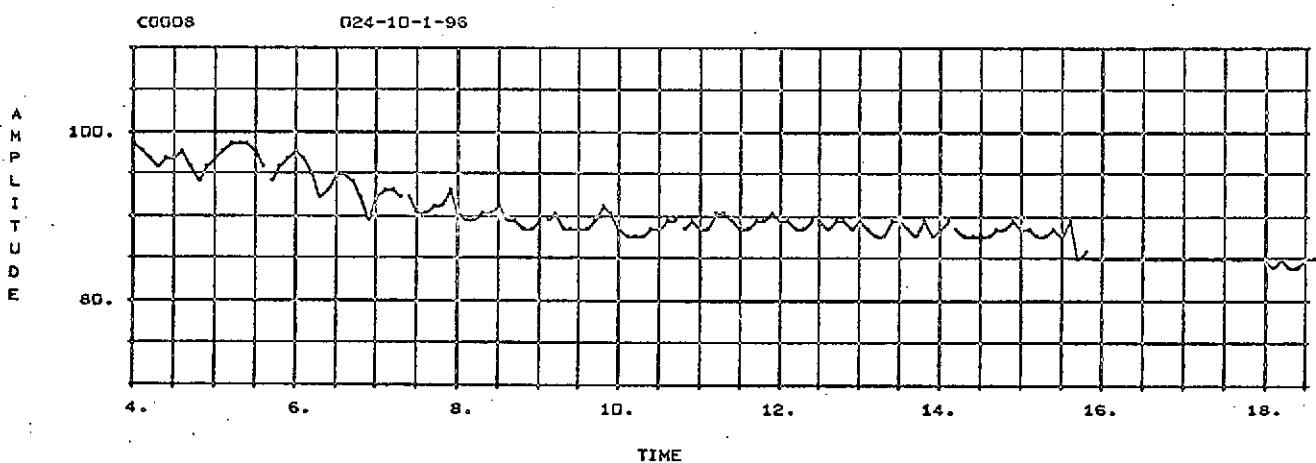
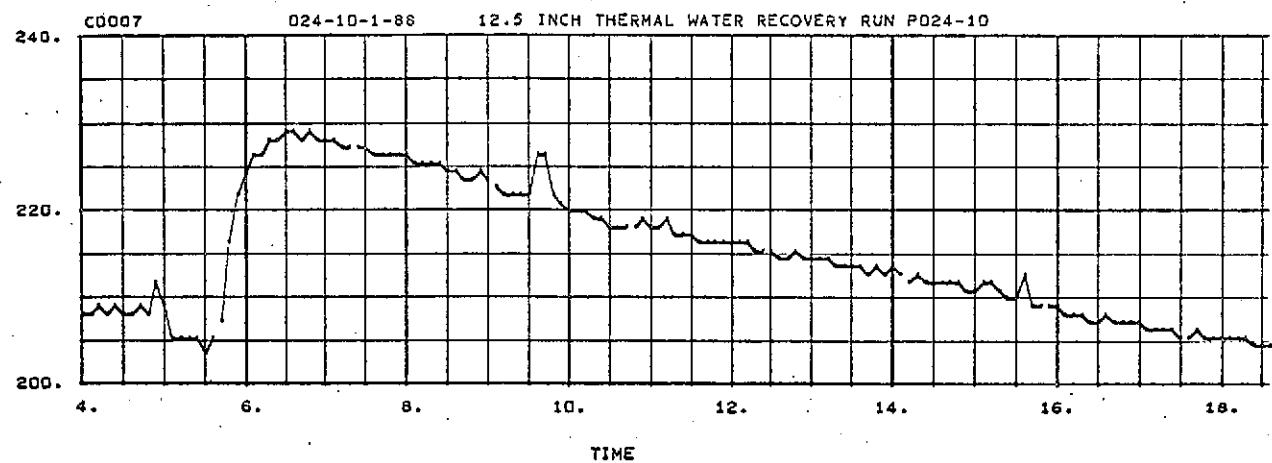




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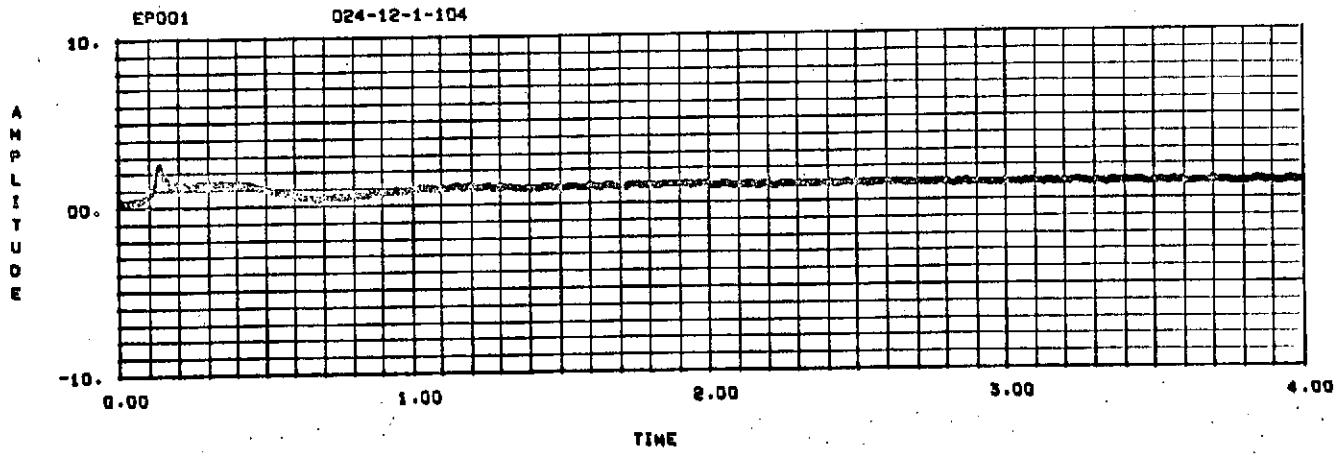
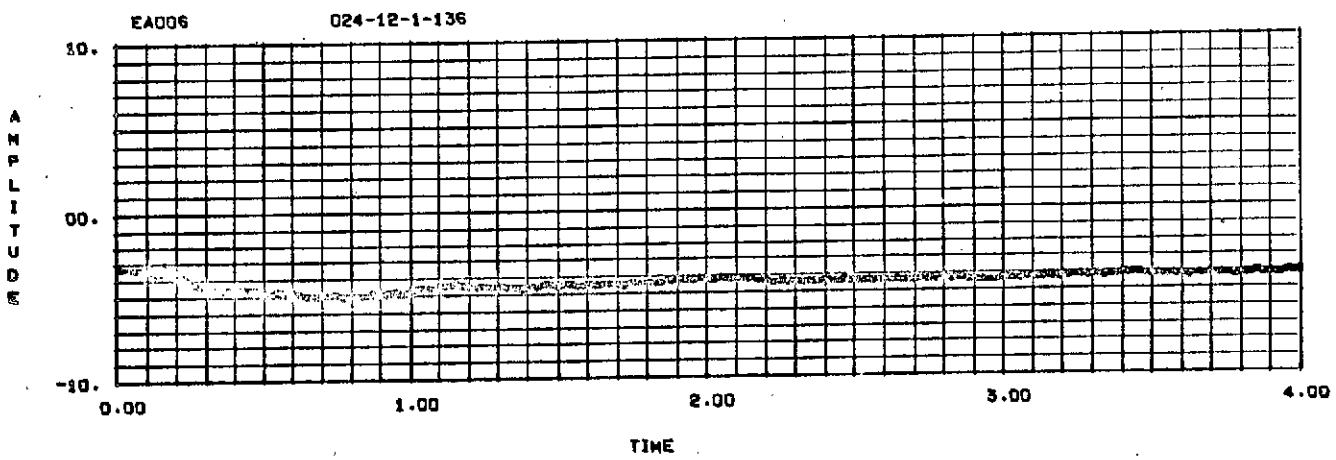
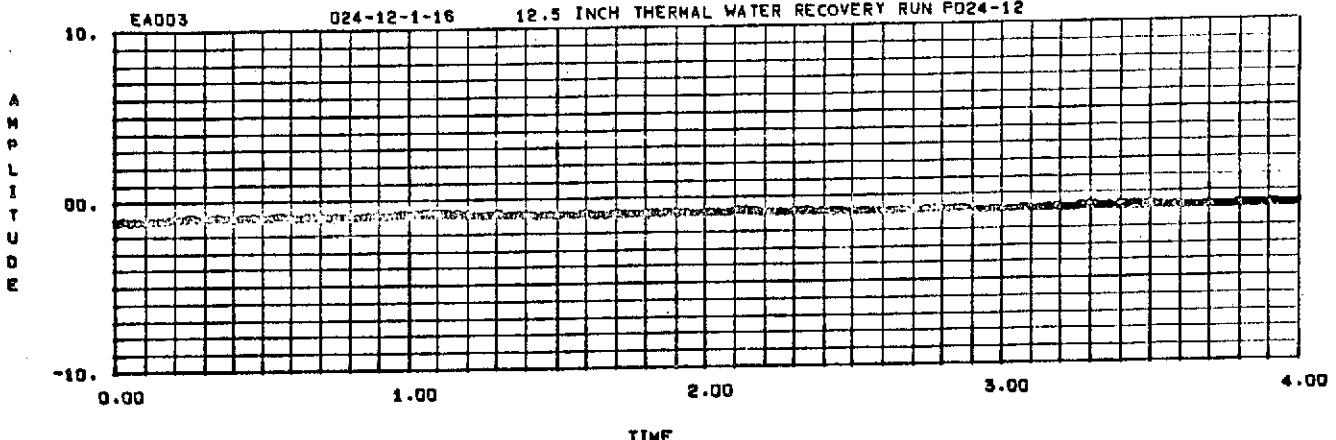
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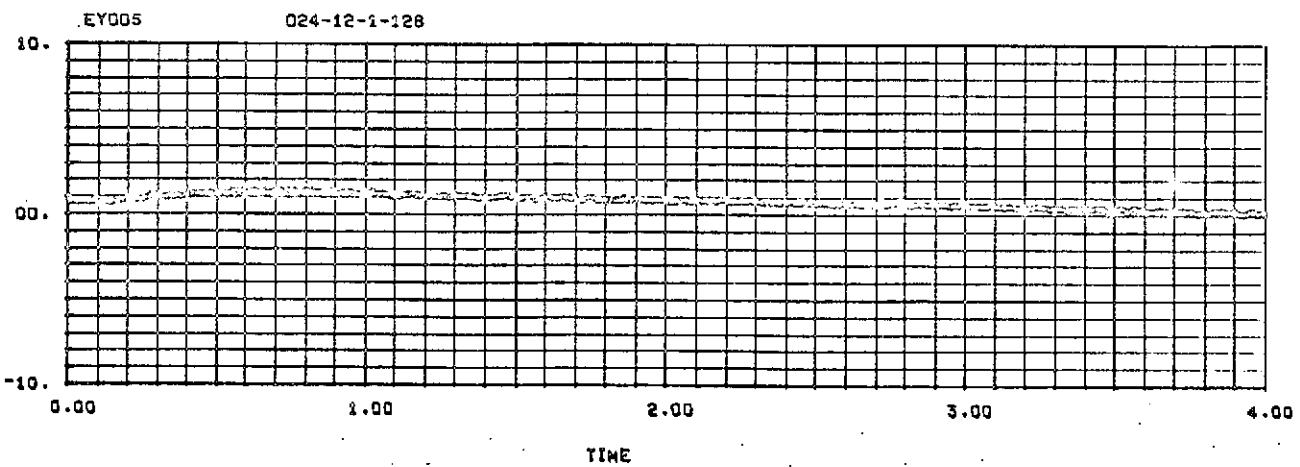
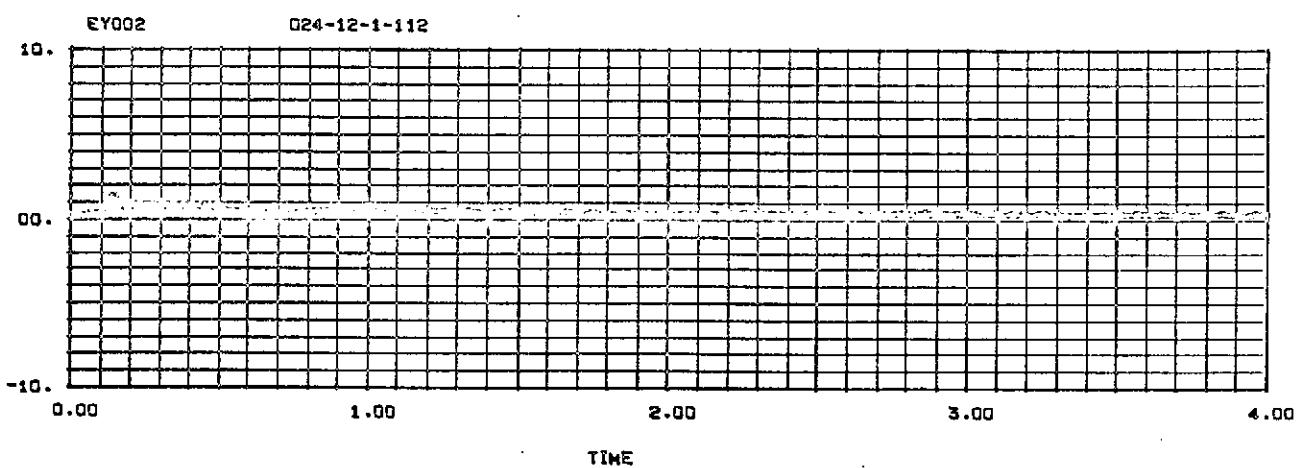
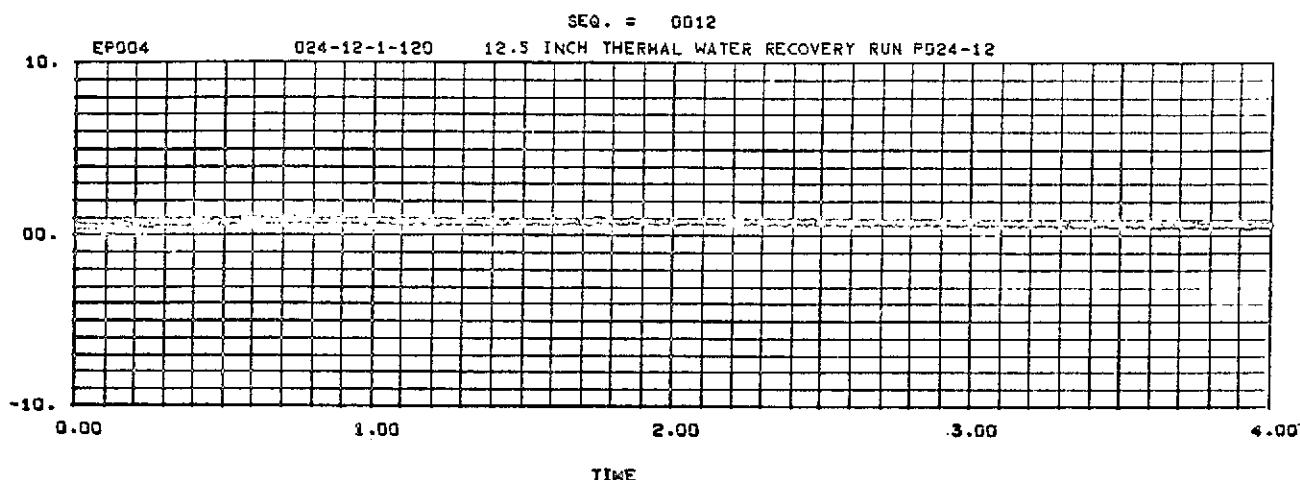


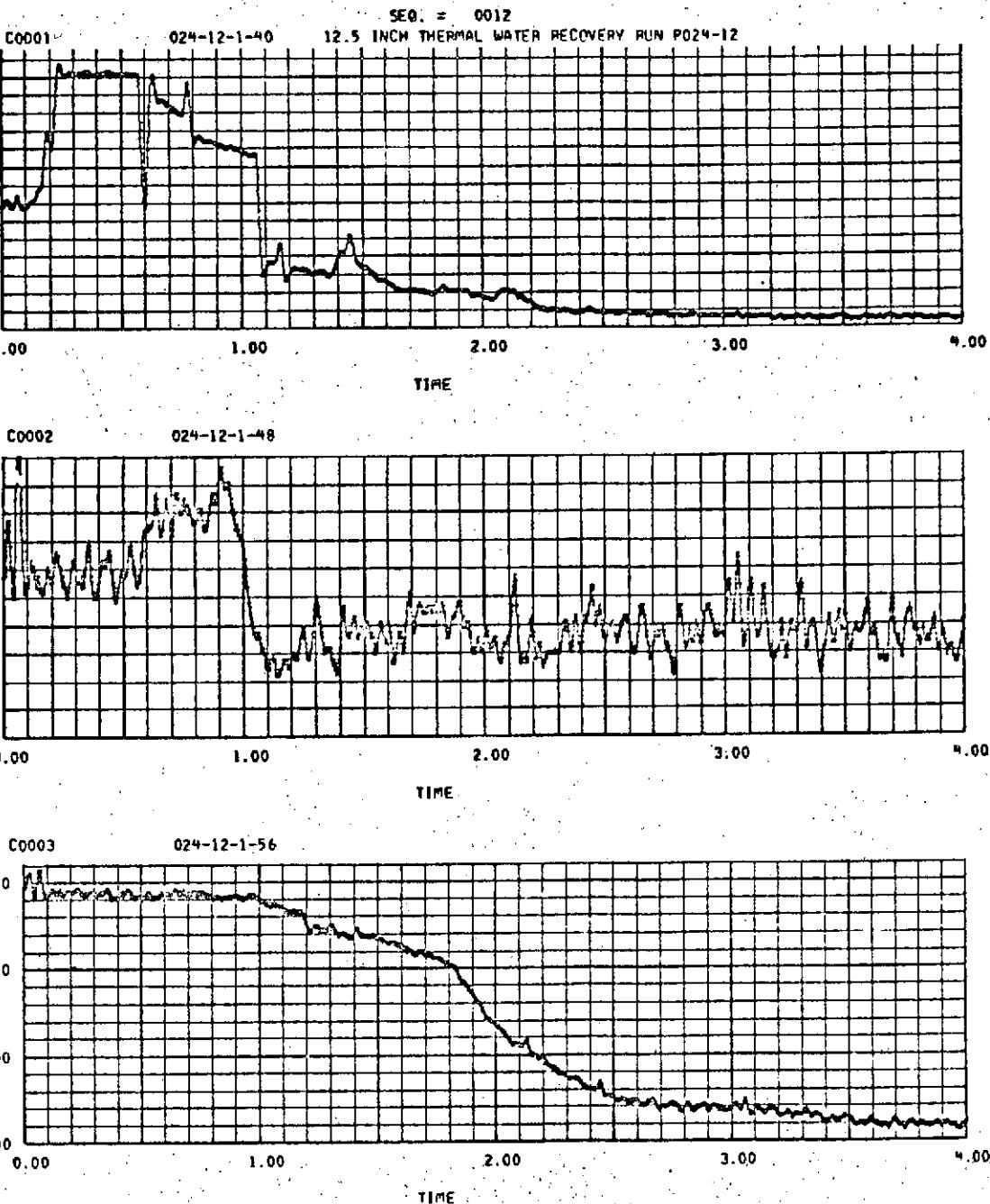
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024-12-1-16 12.5 INCH THERMAL WATER RECOVERY RUN F024-12



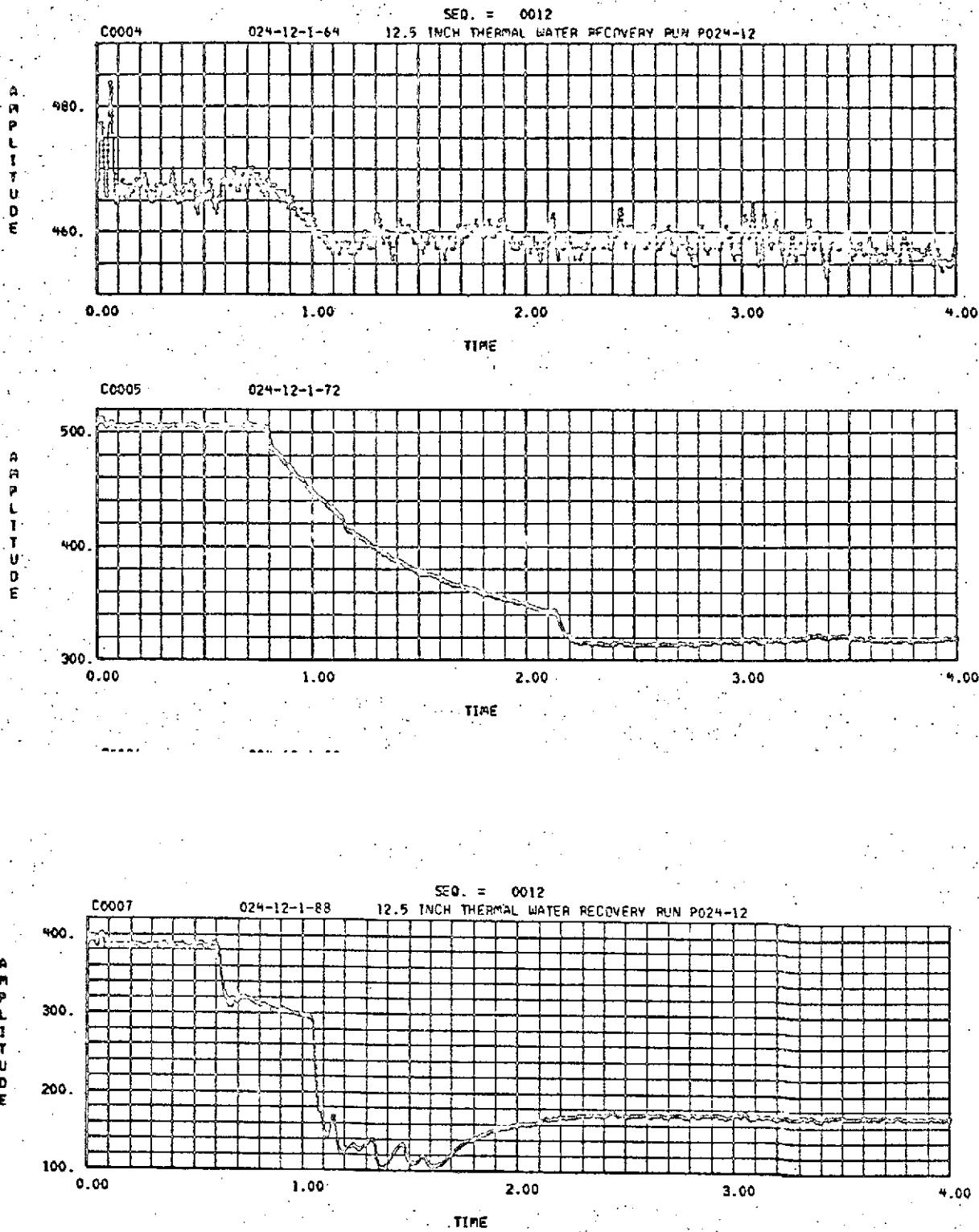
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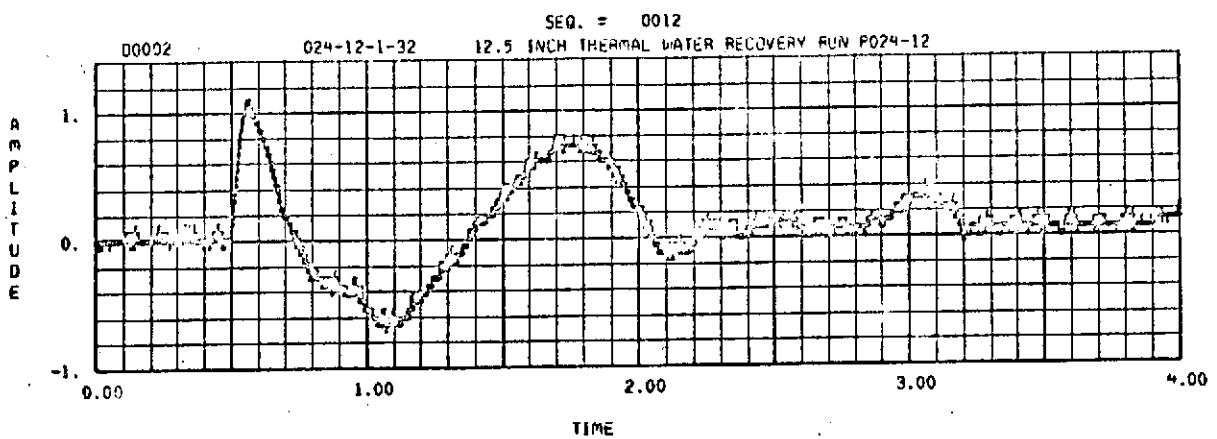
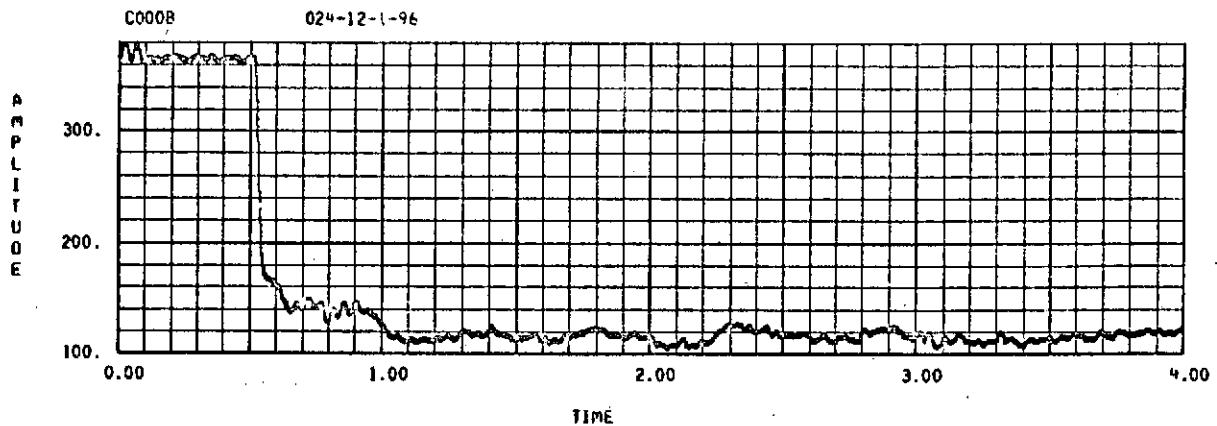




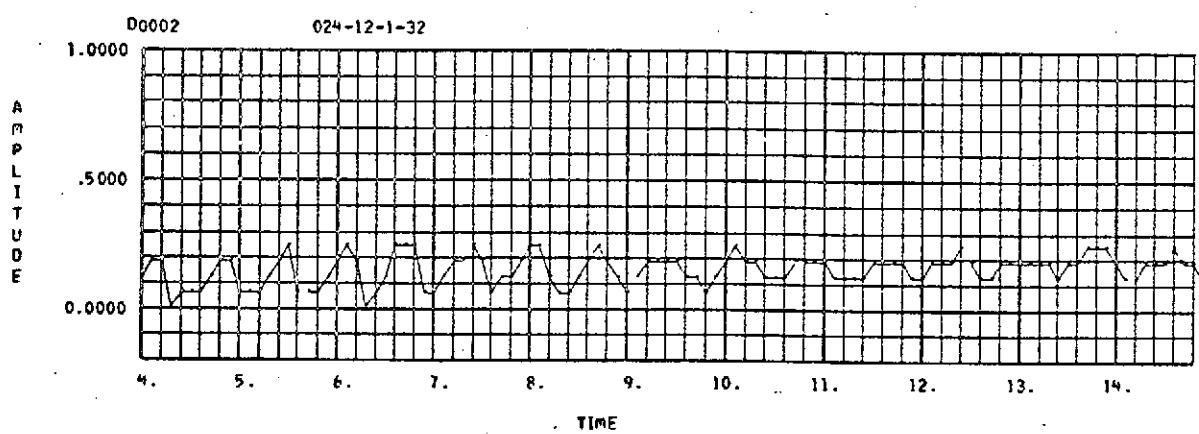
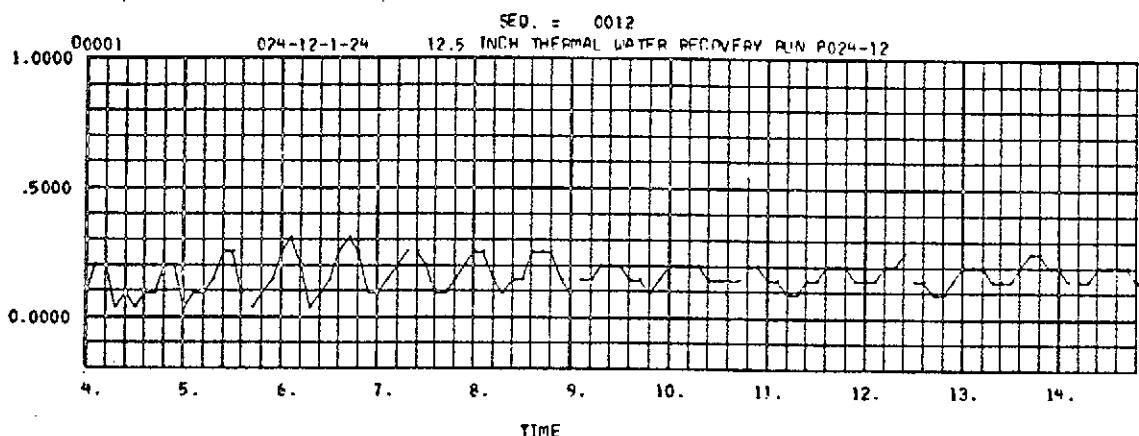
B-97

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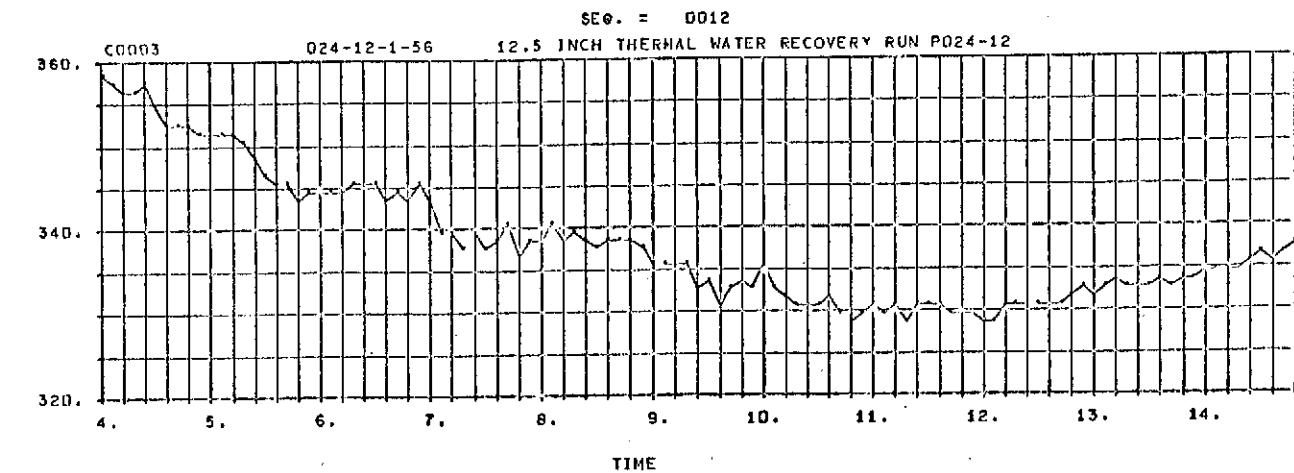
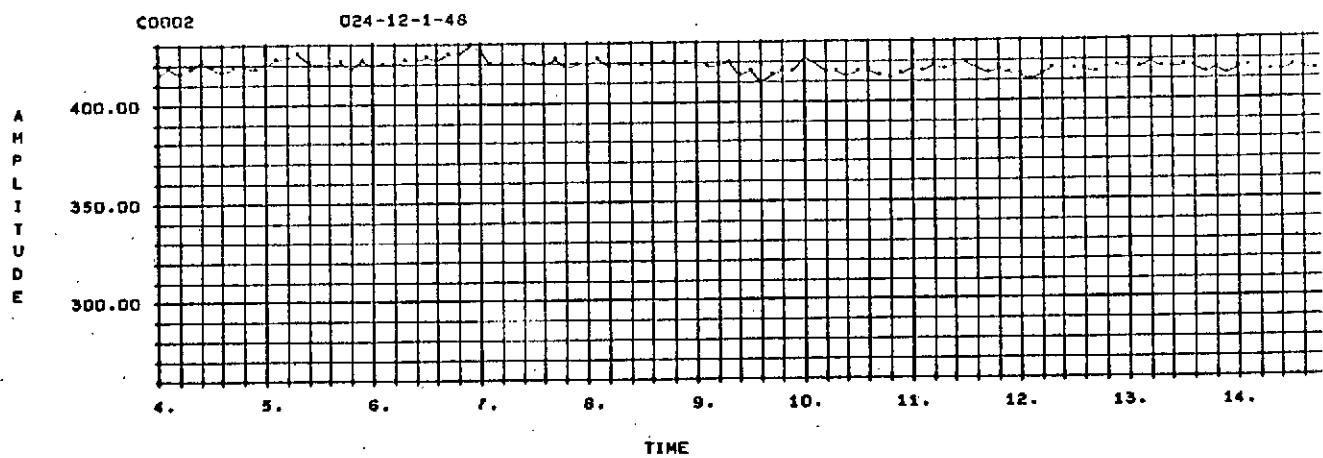
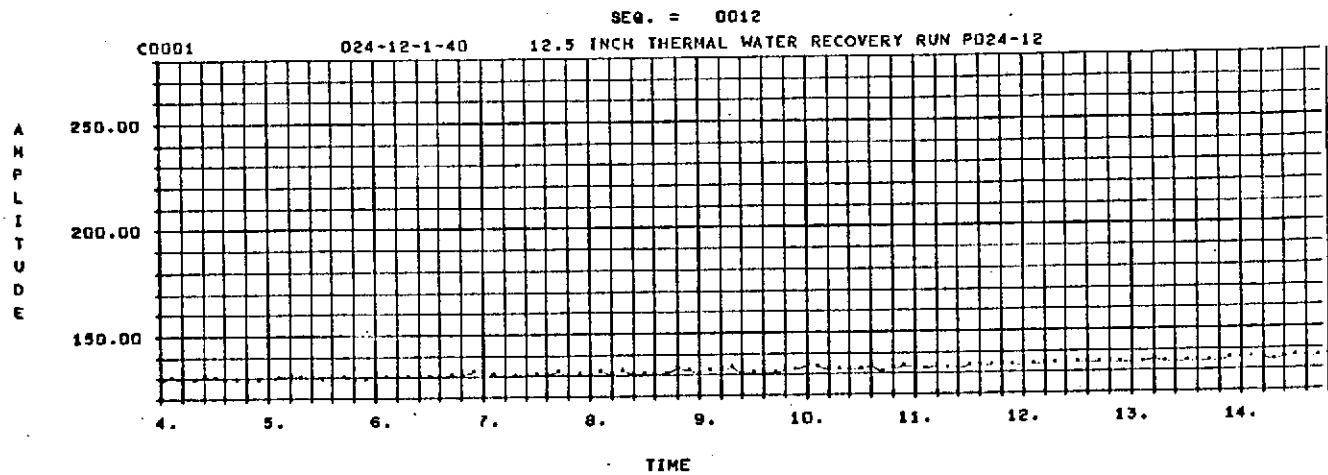




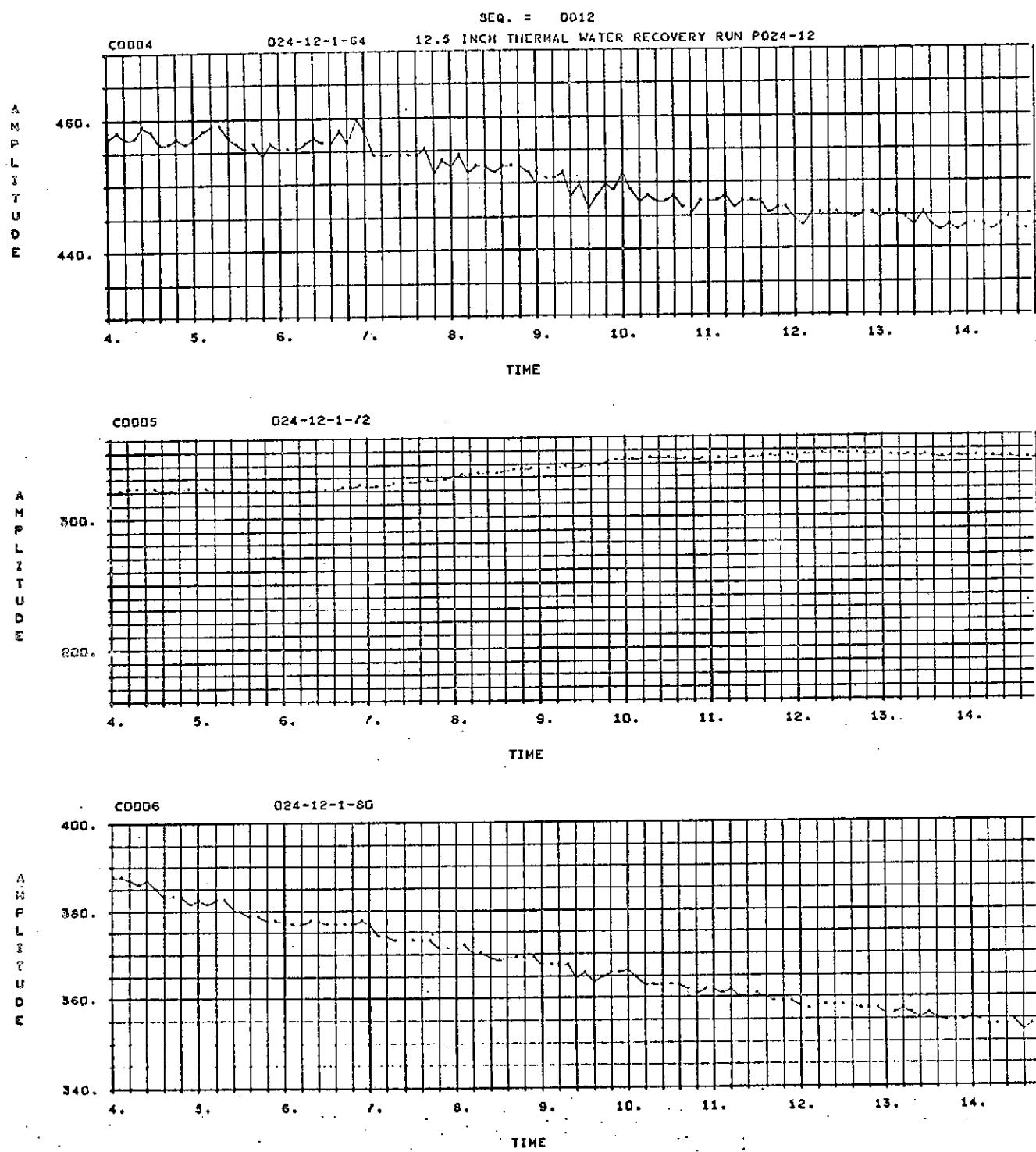
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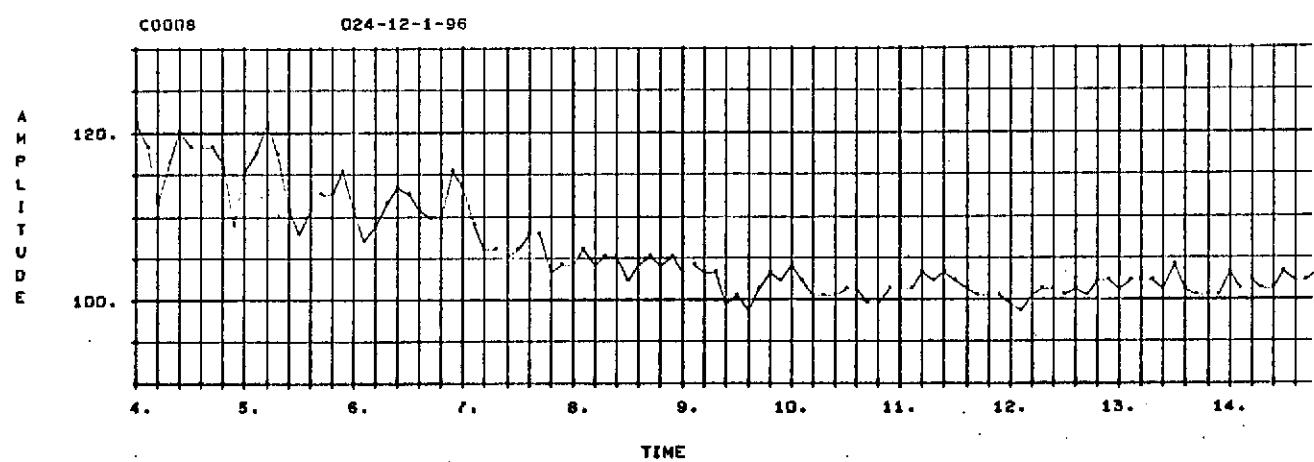
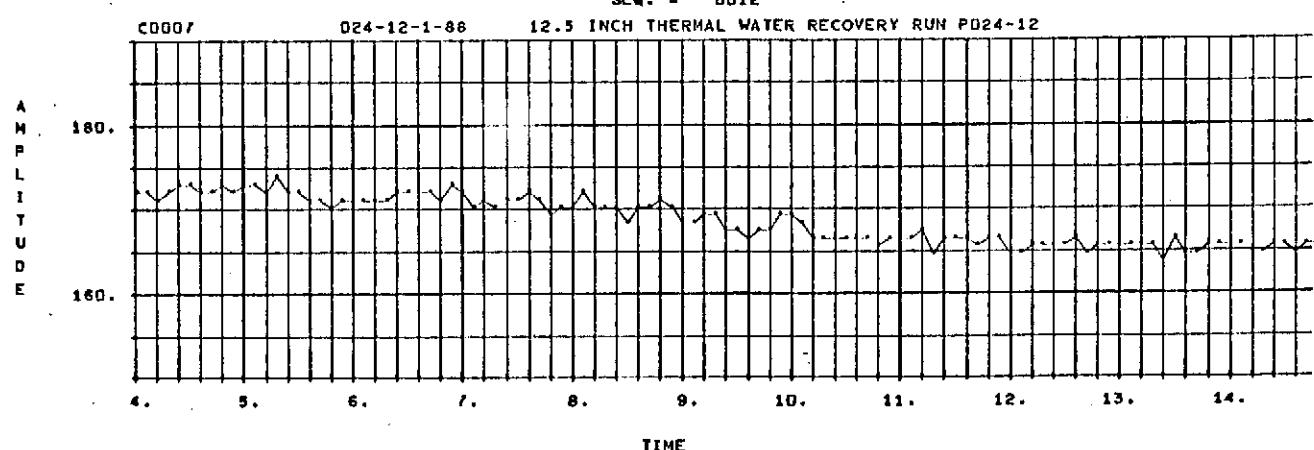
B-100



B-101 REPRODUCIBILITY OF THE
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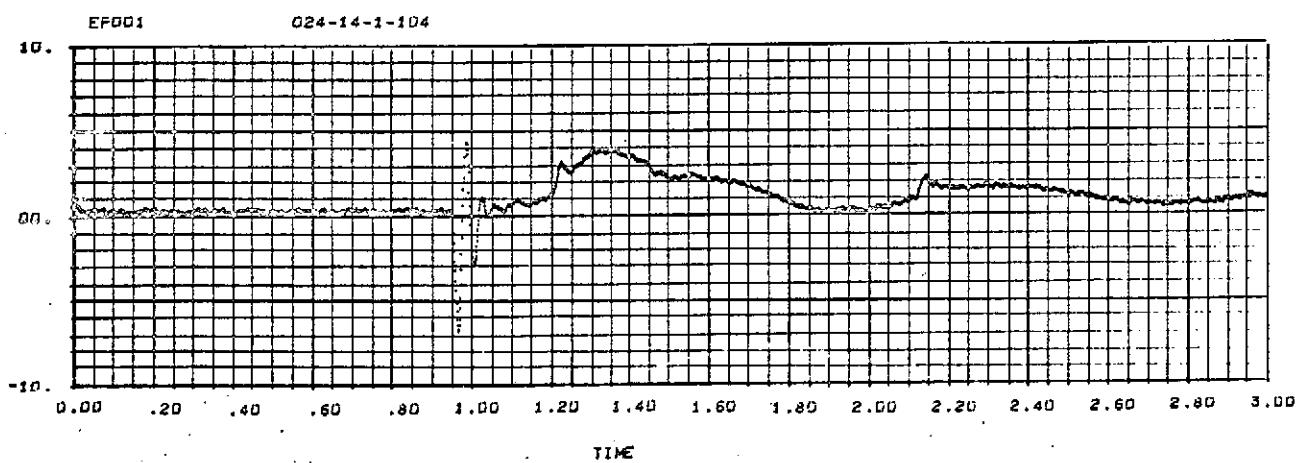
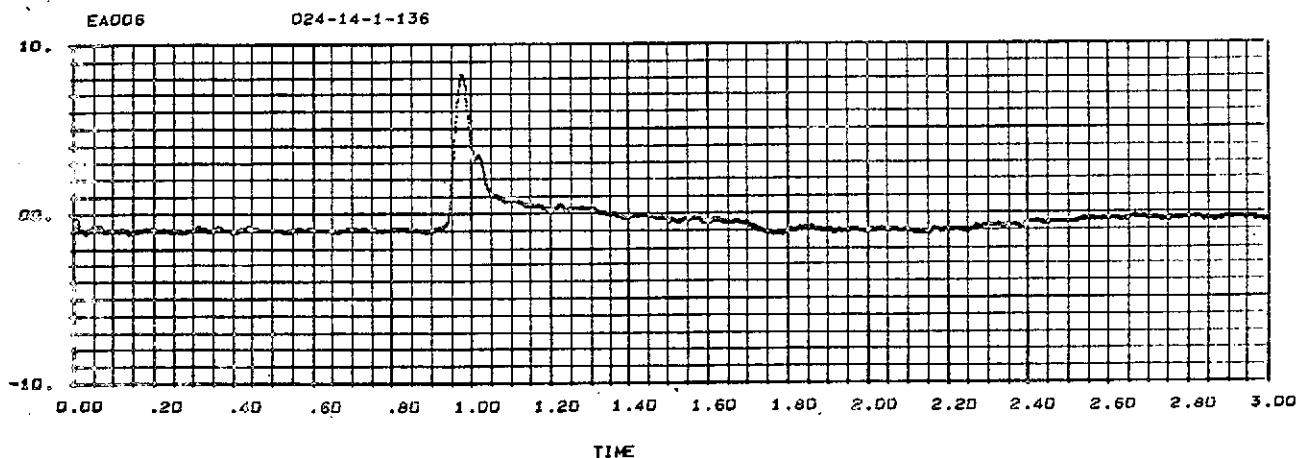
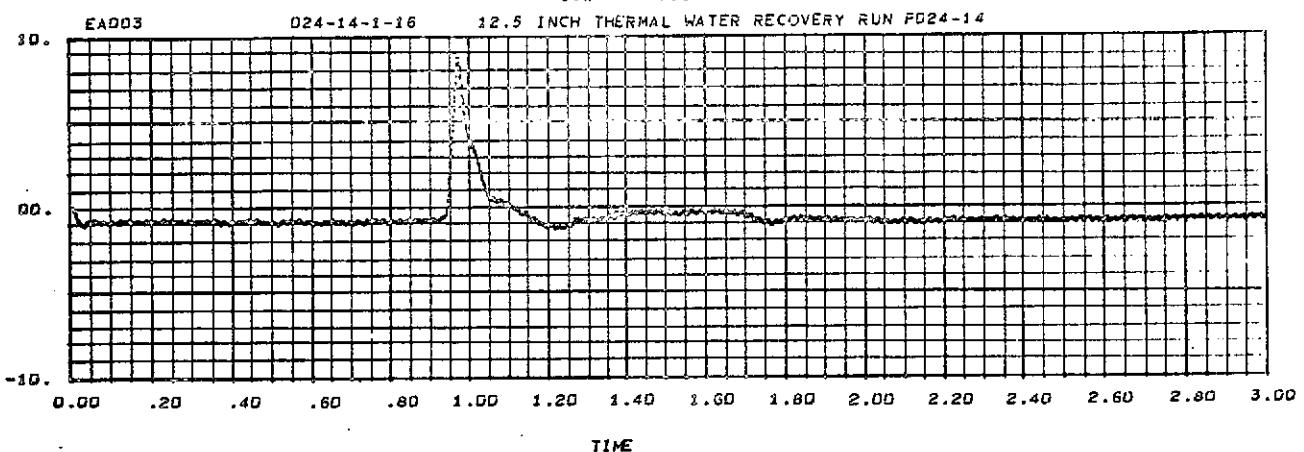
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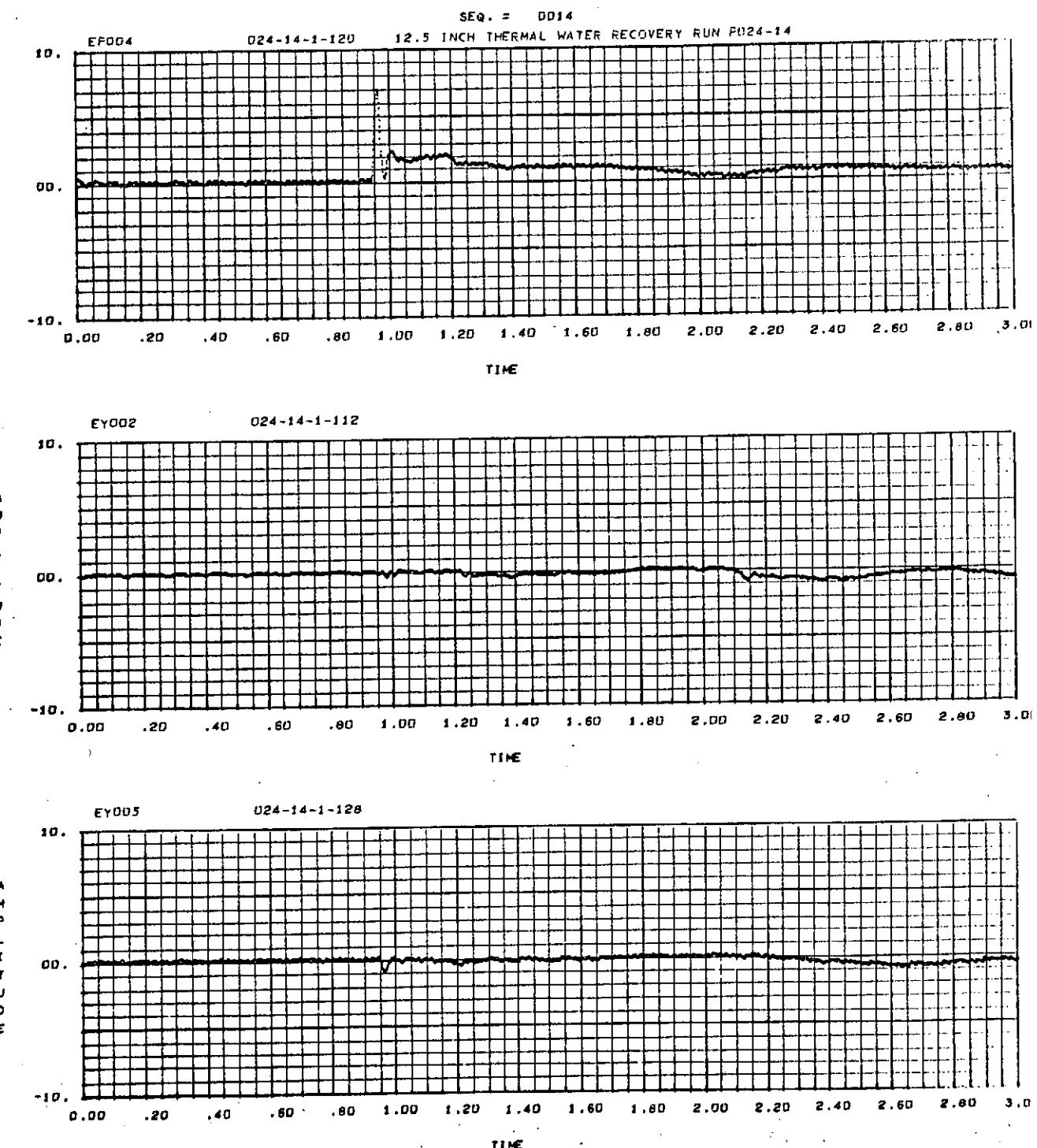
B-103

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SEQ. #: 0014

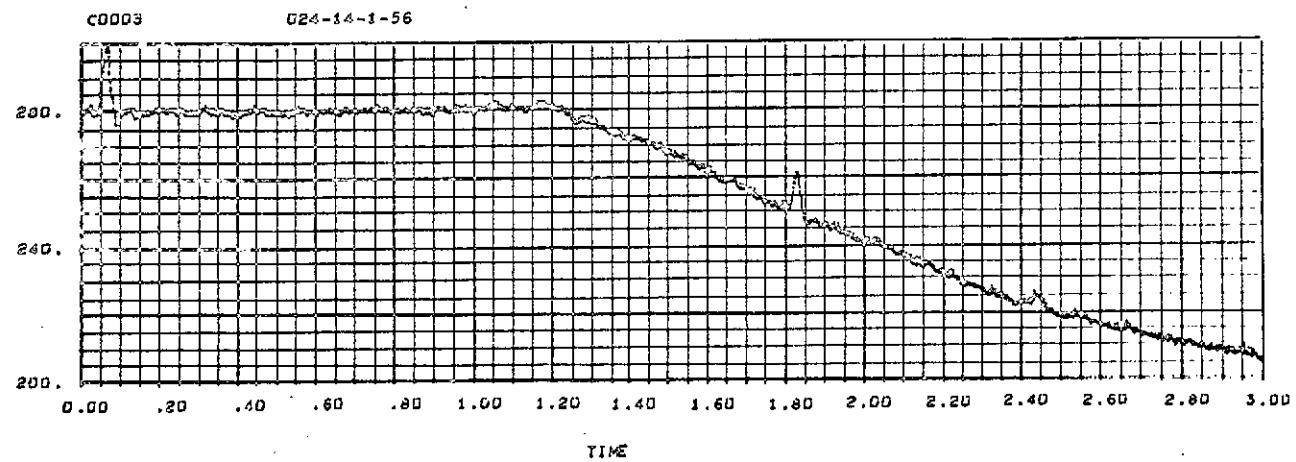
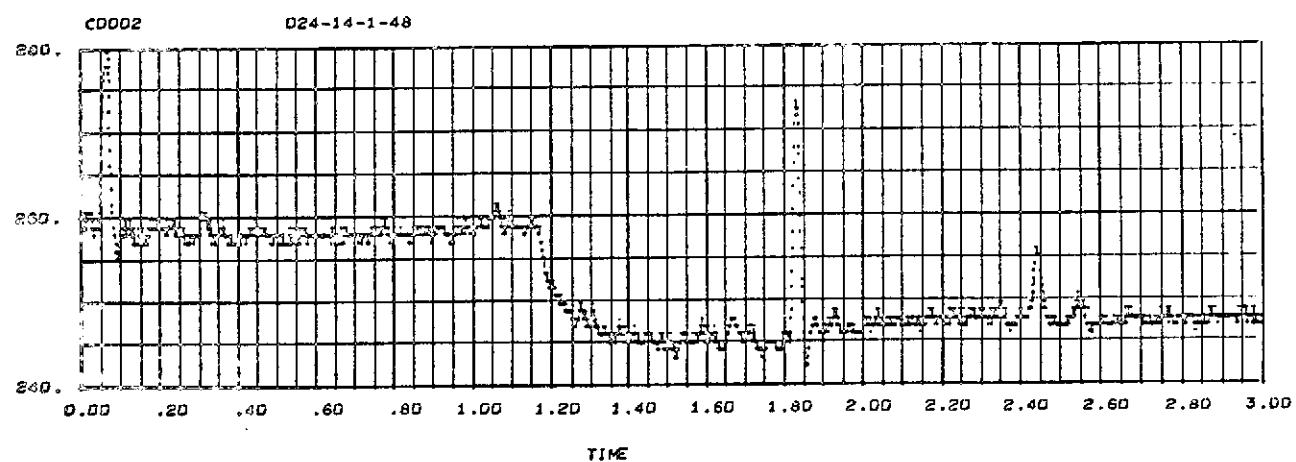
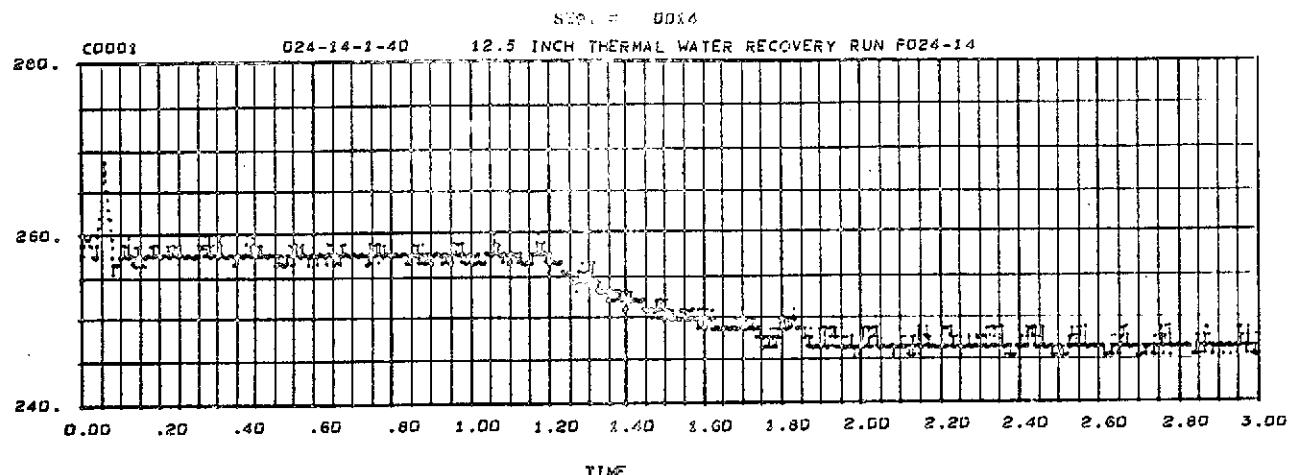


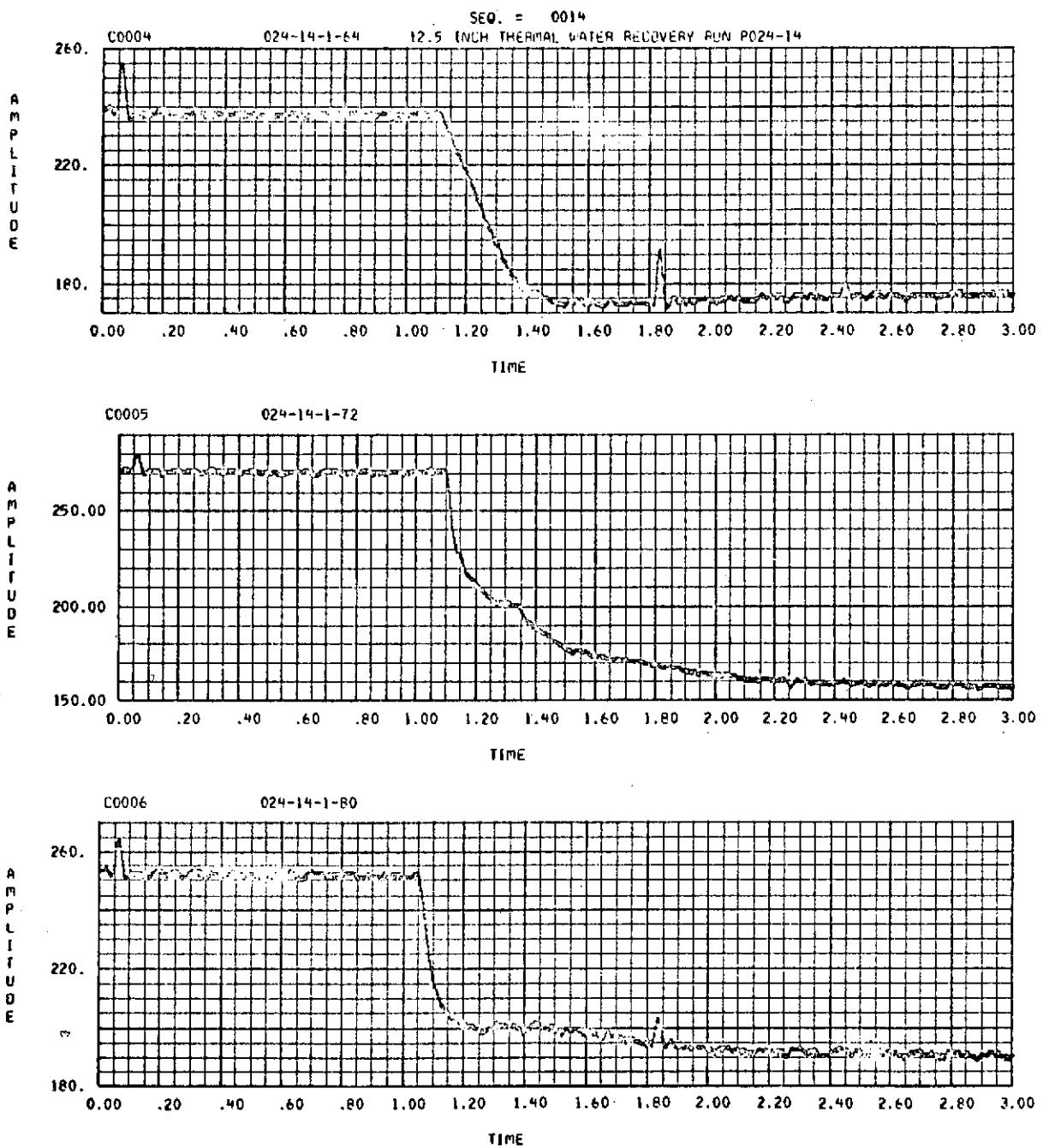
B-104



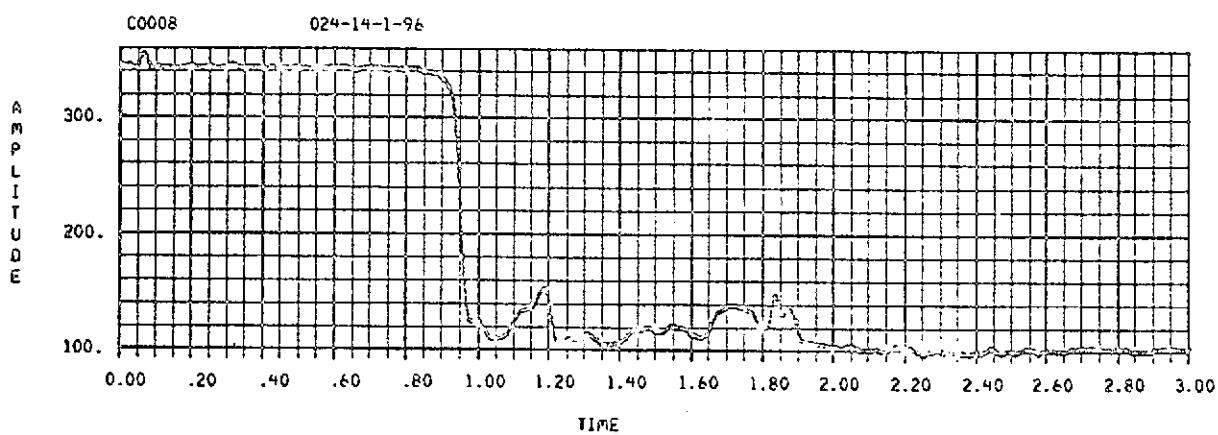
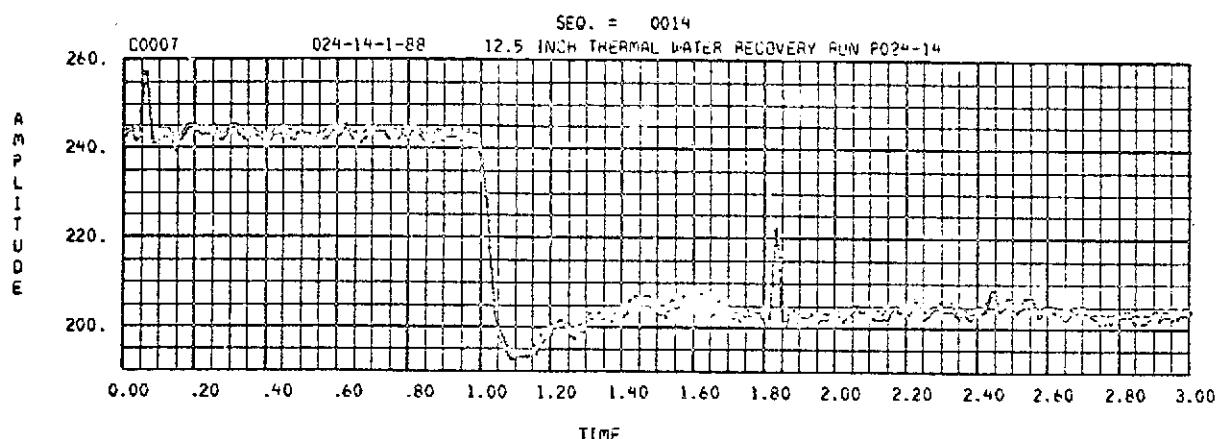
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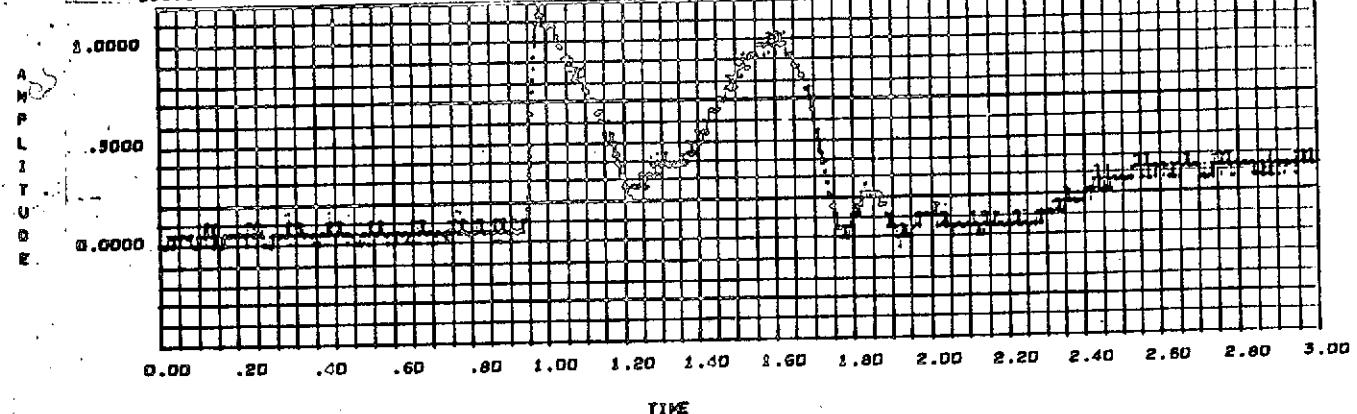


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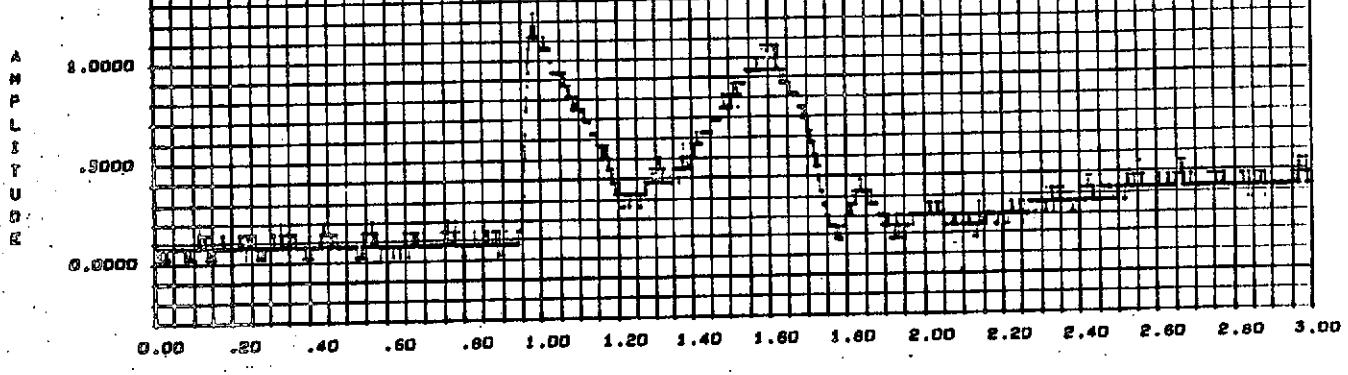
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024-14-1-24

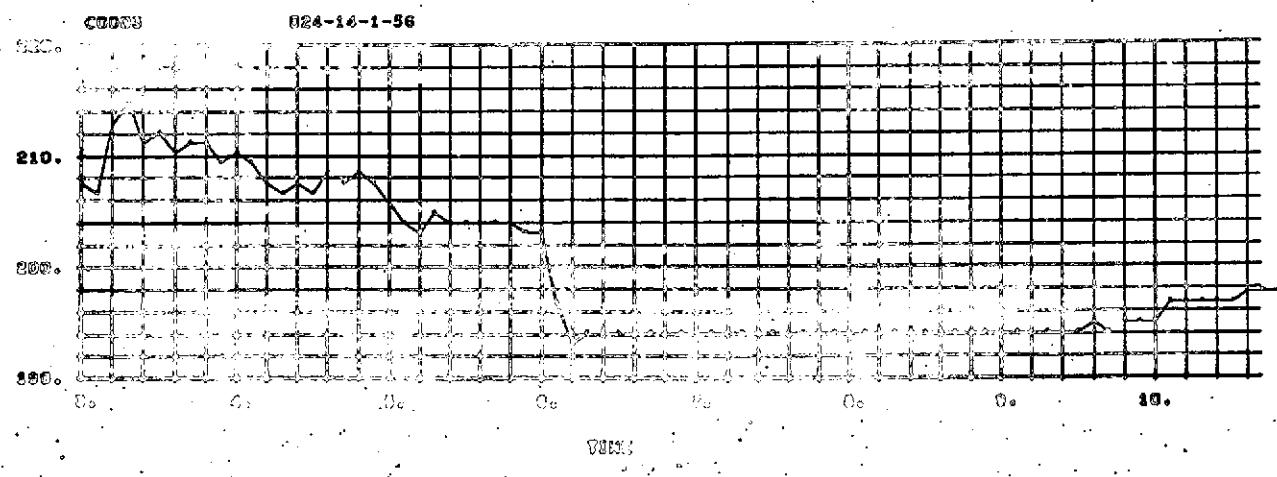
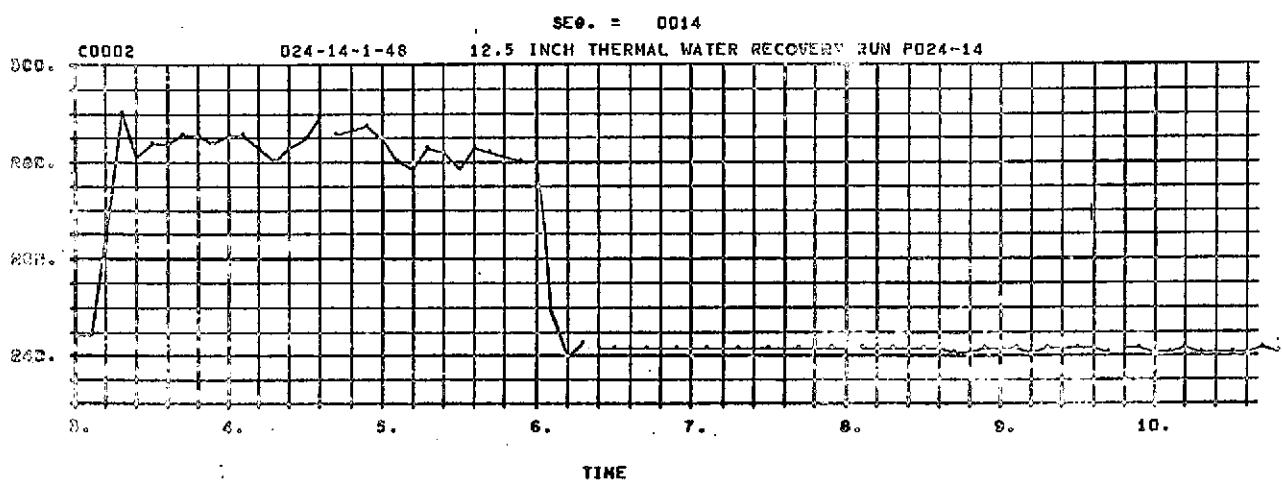
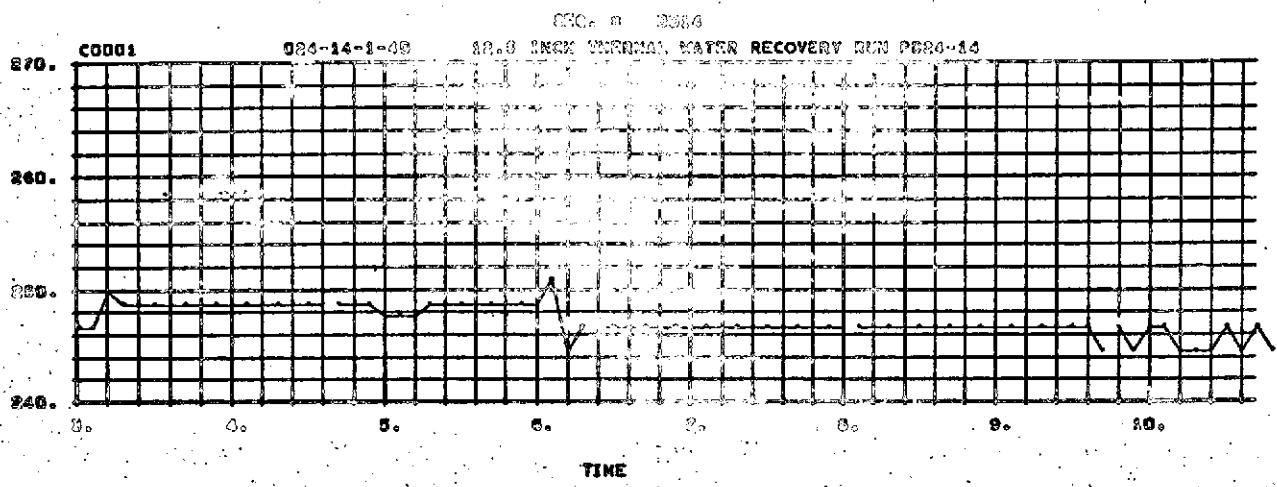
SEQ. # DD14
12.5 INCH THERMAL WATER RECOVERY RUN PD24-14

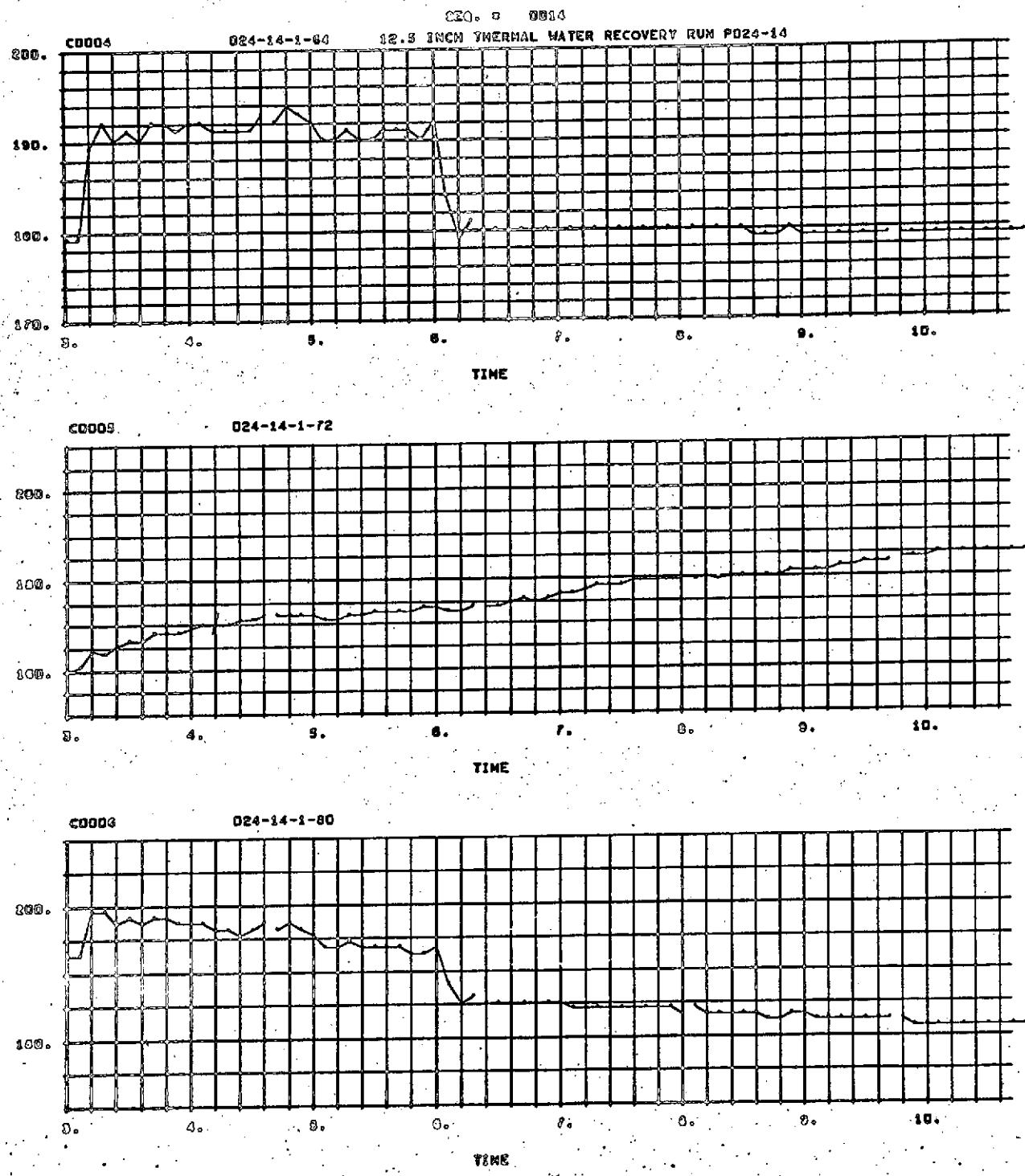
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024-14-1-32

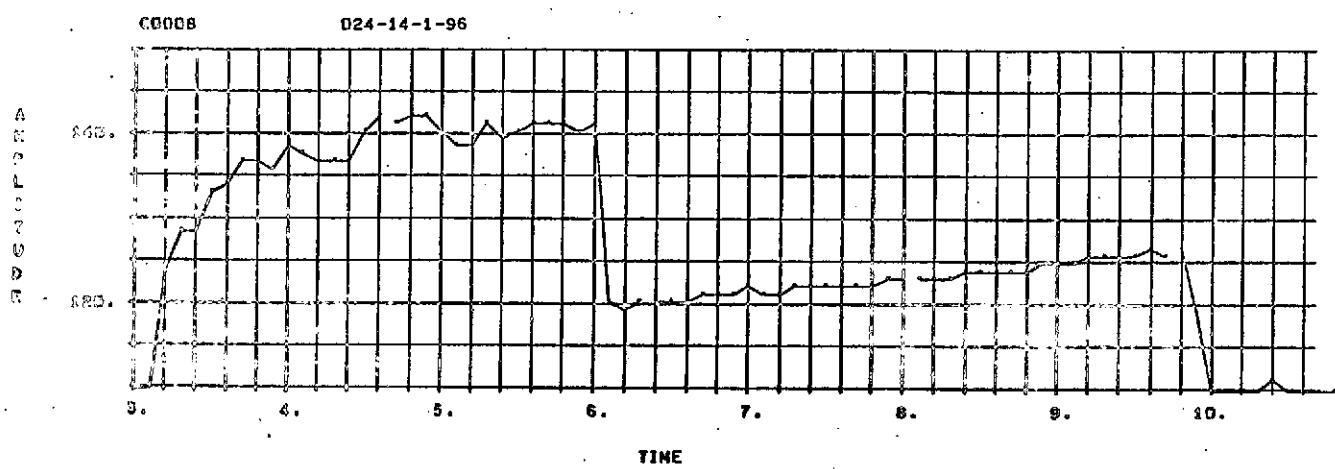
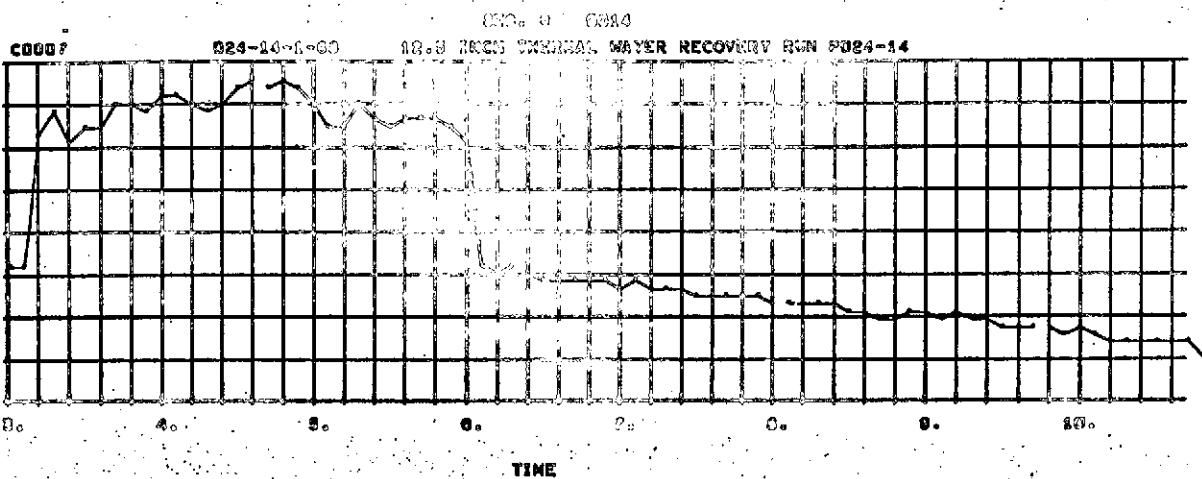


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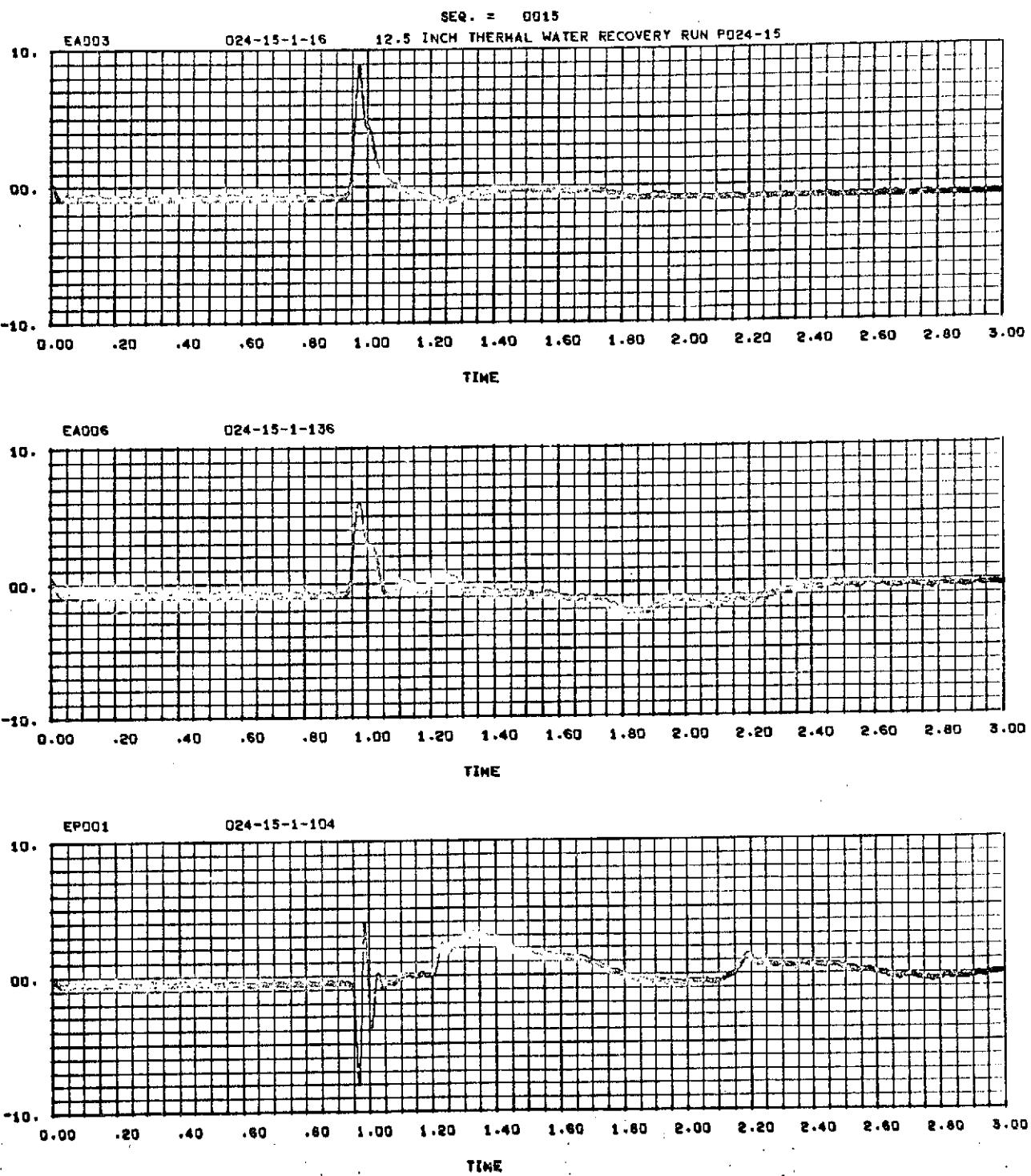




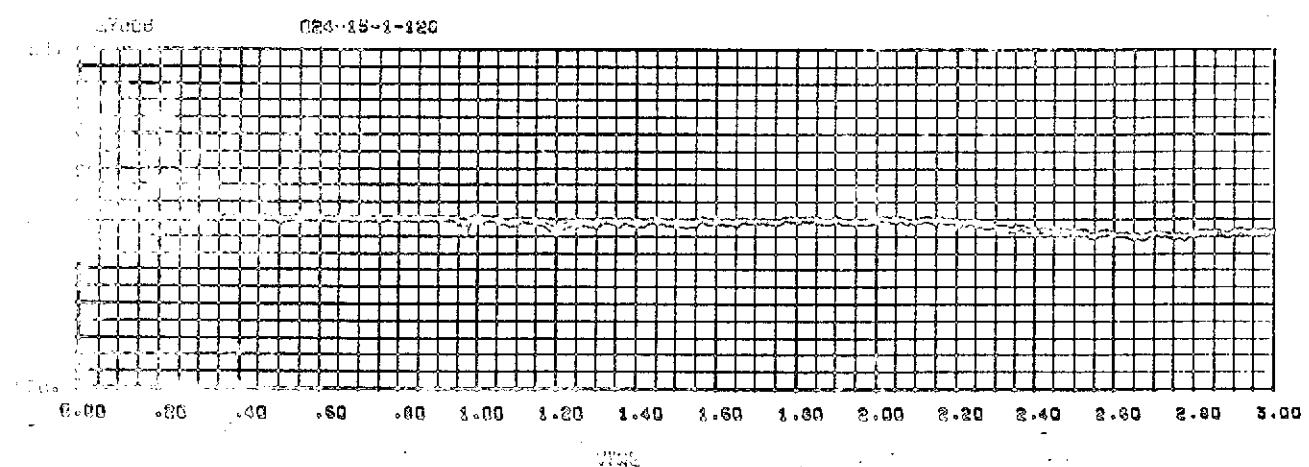
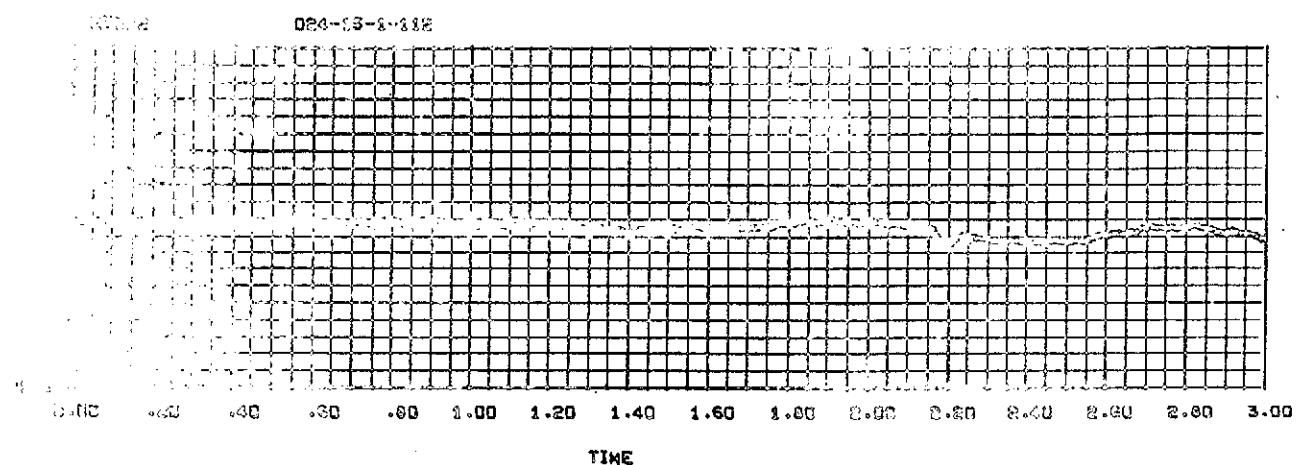
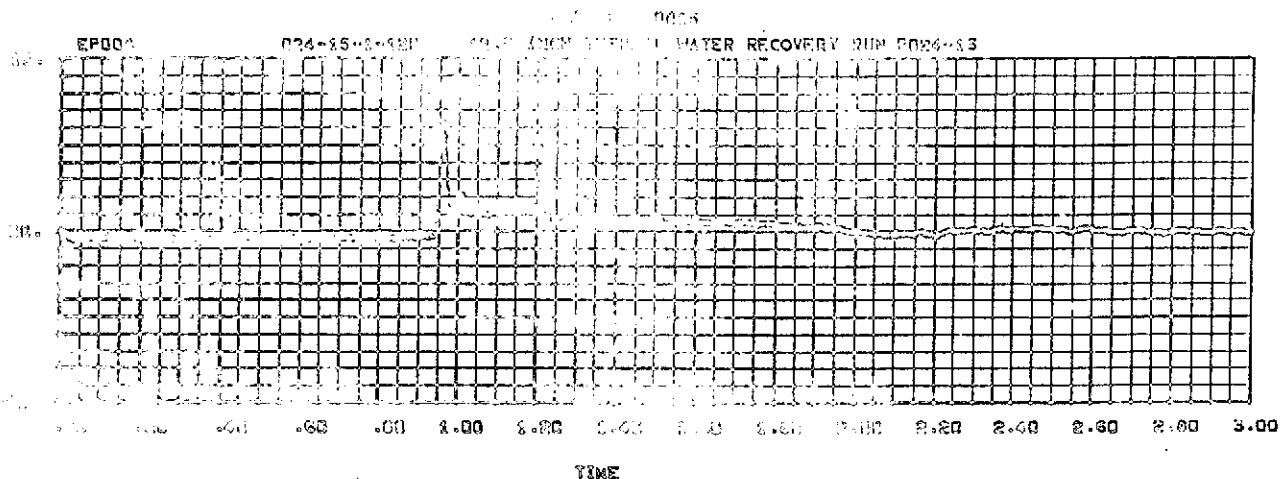
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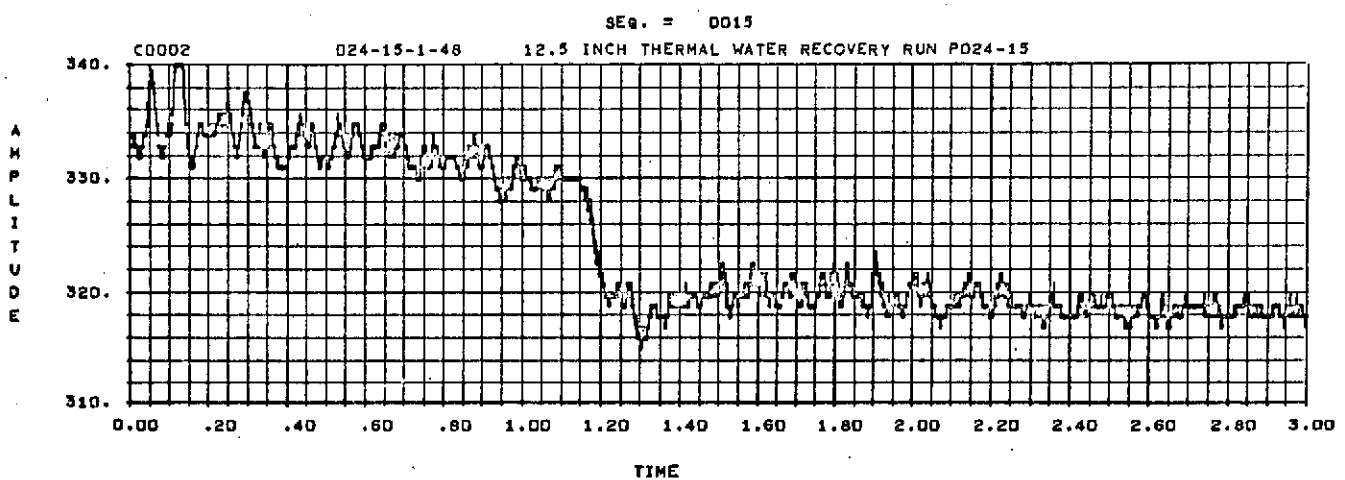
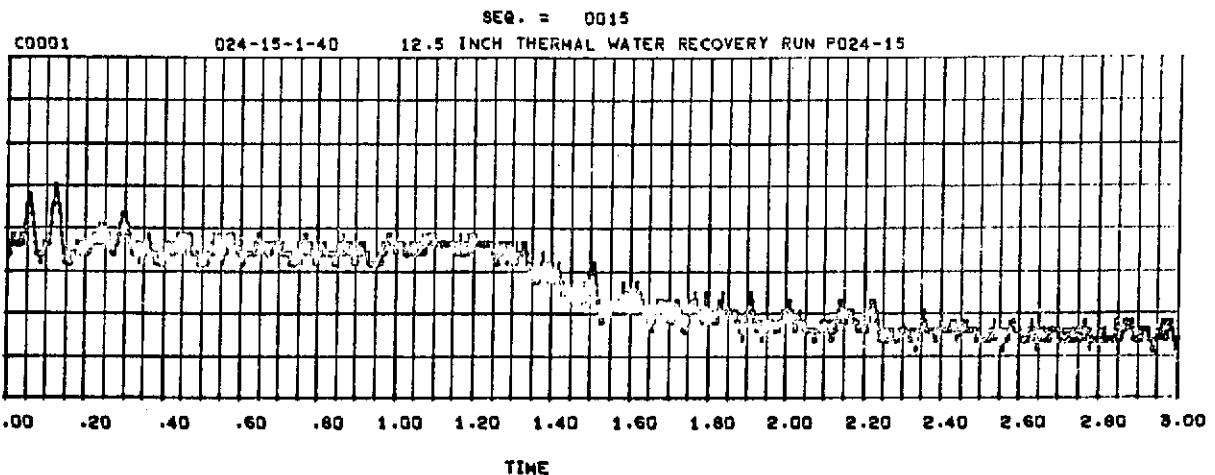
X-112



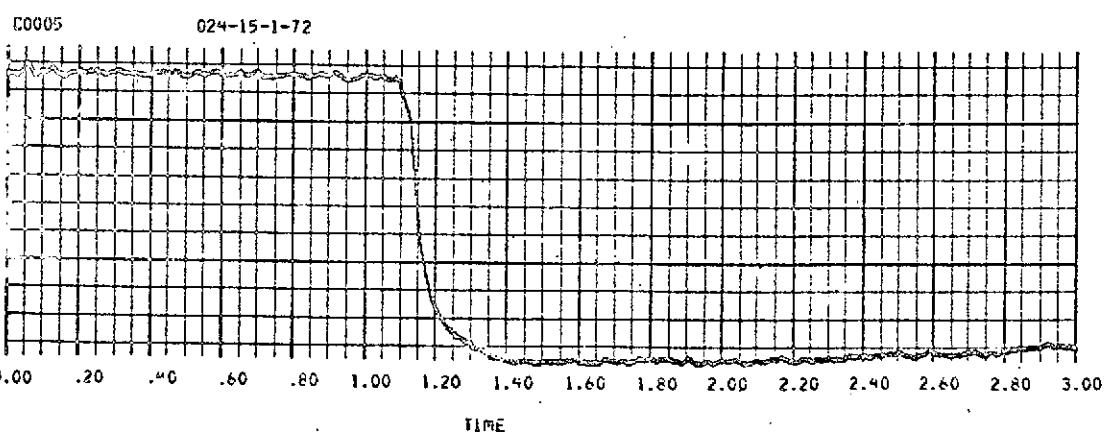
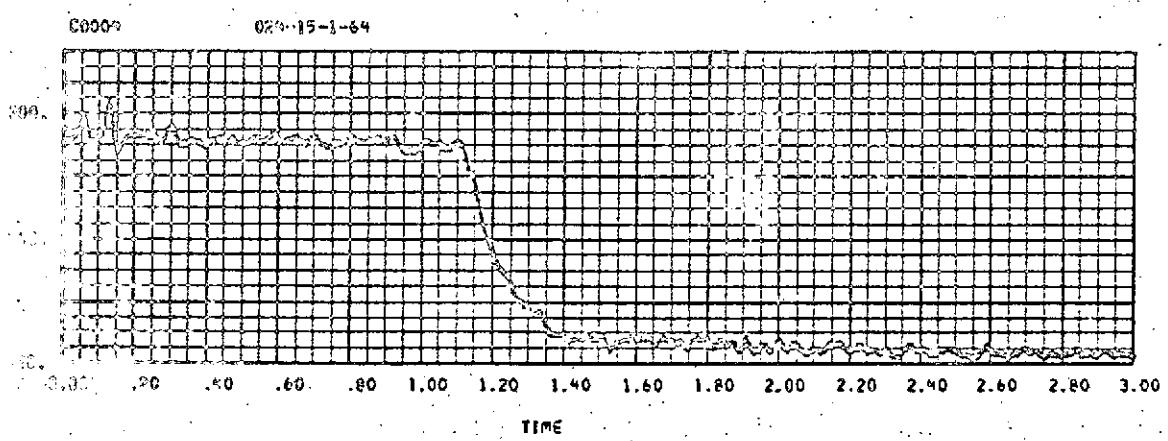
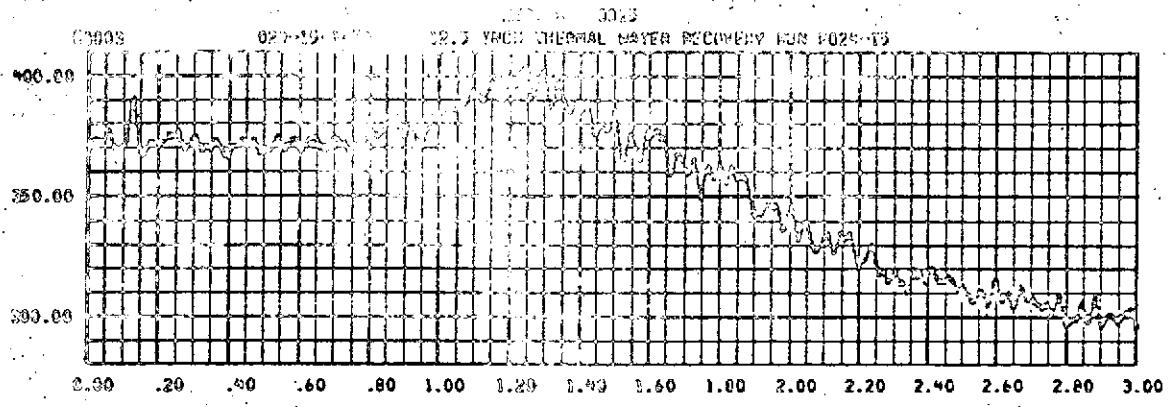
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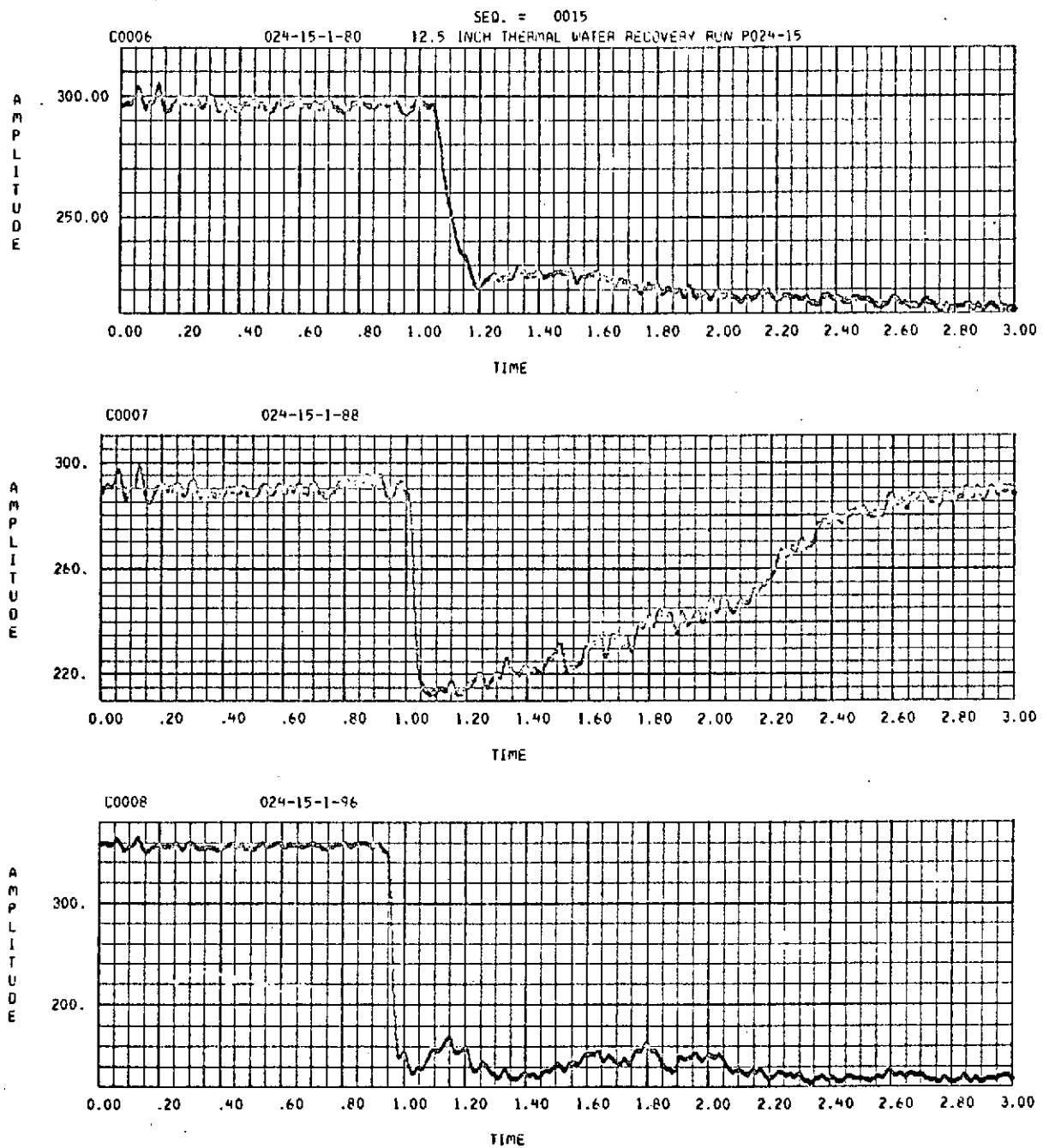


P-110

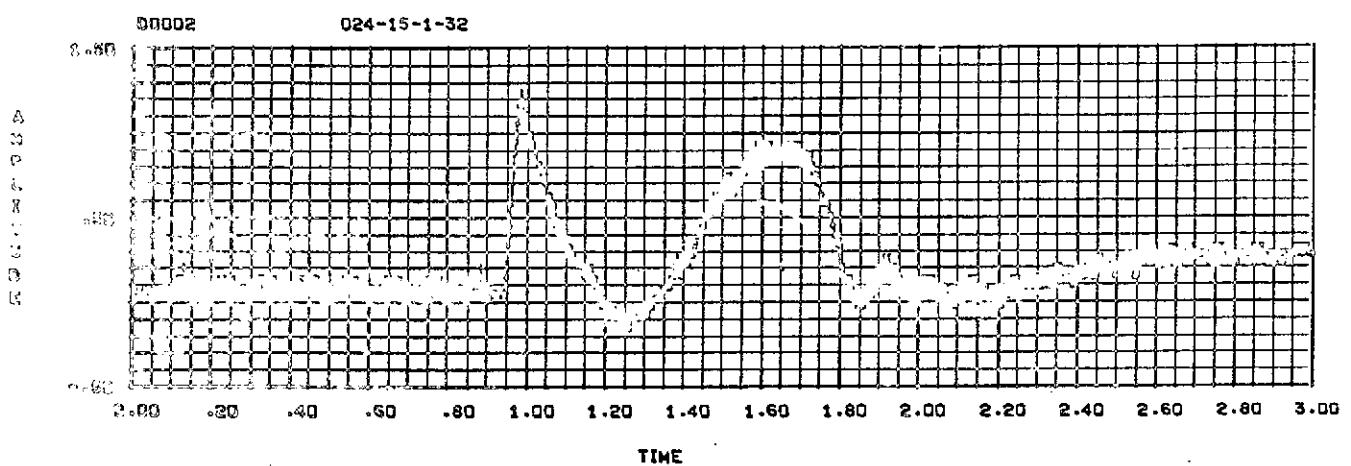
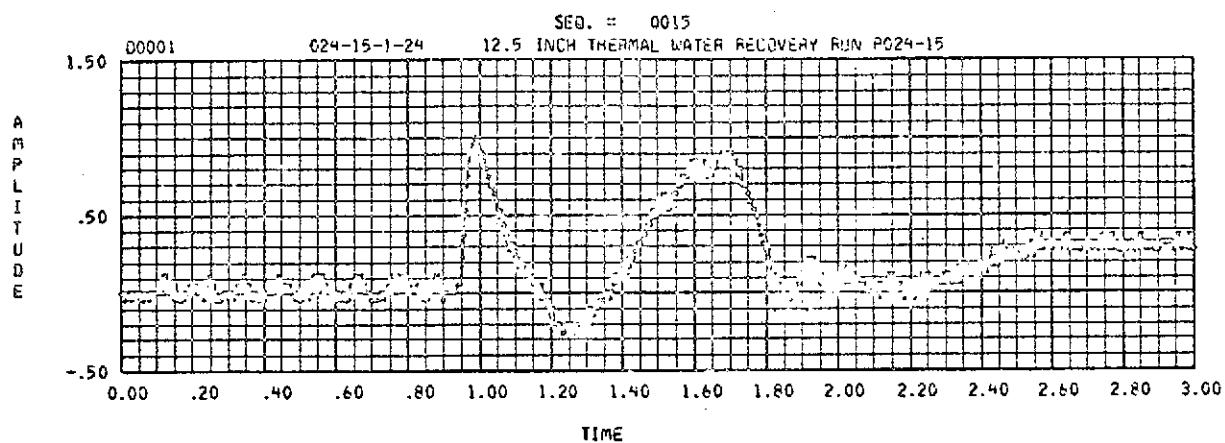


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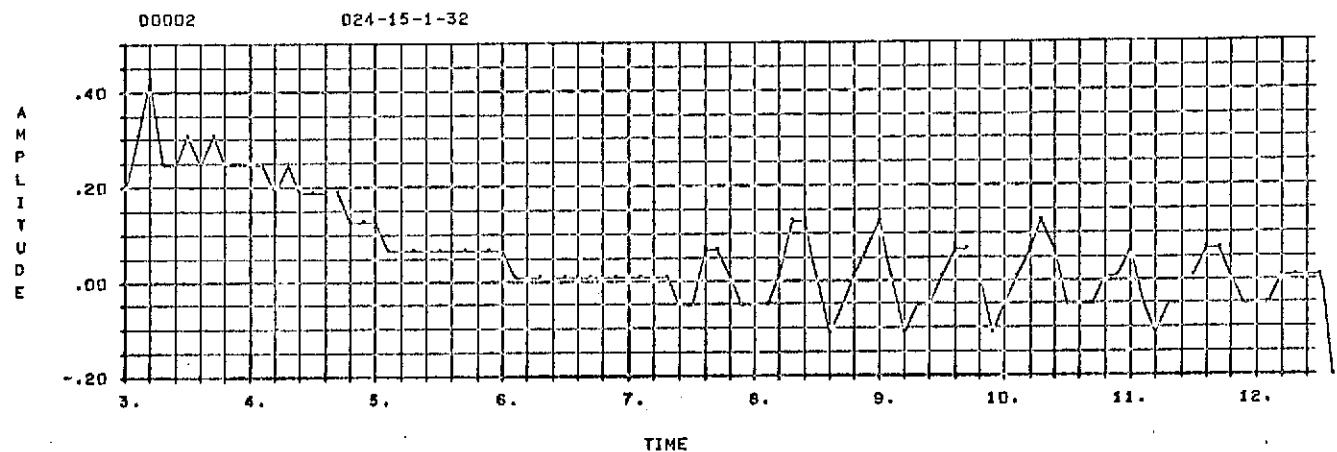
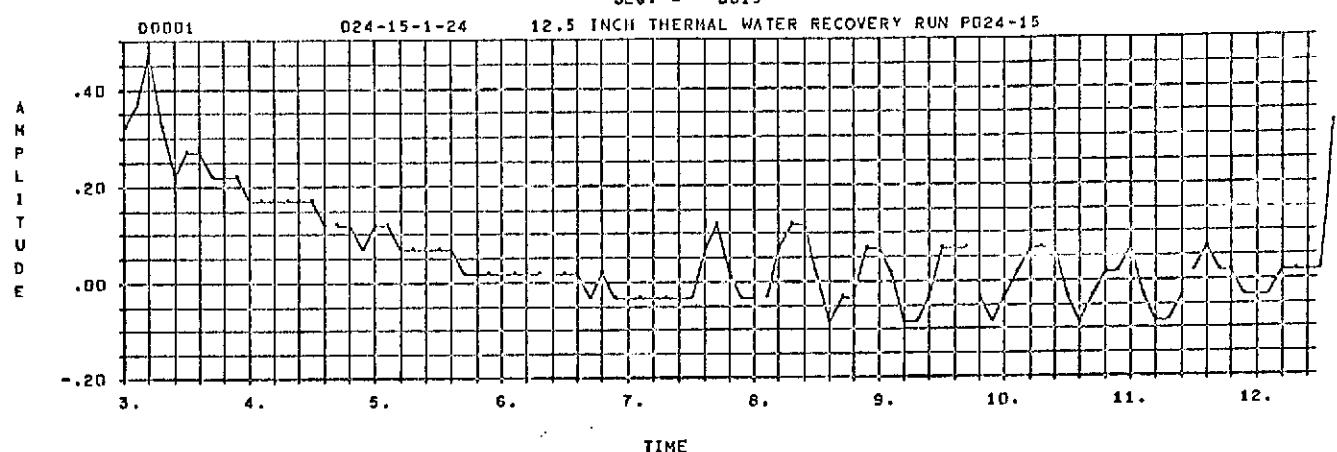


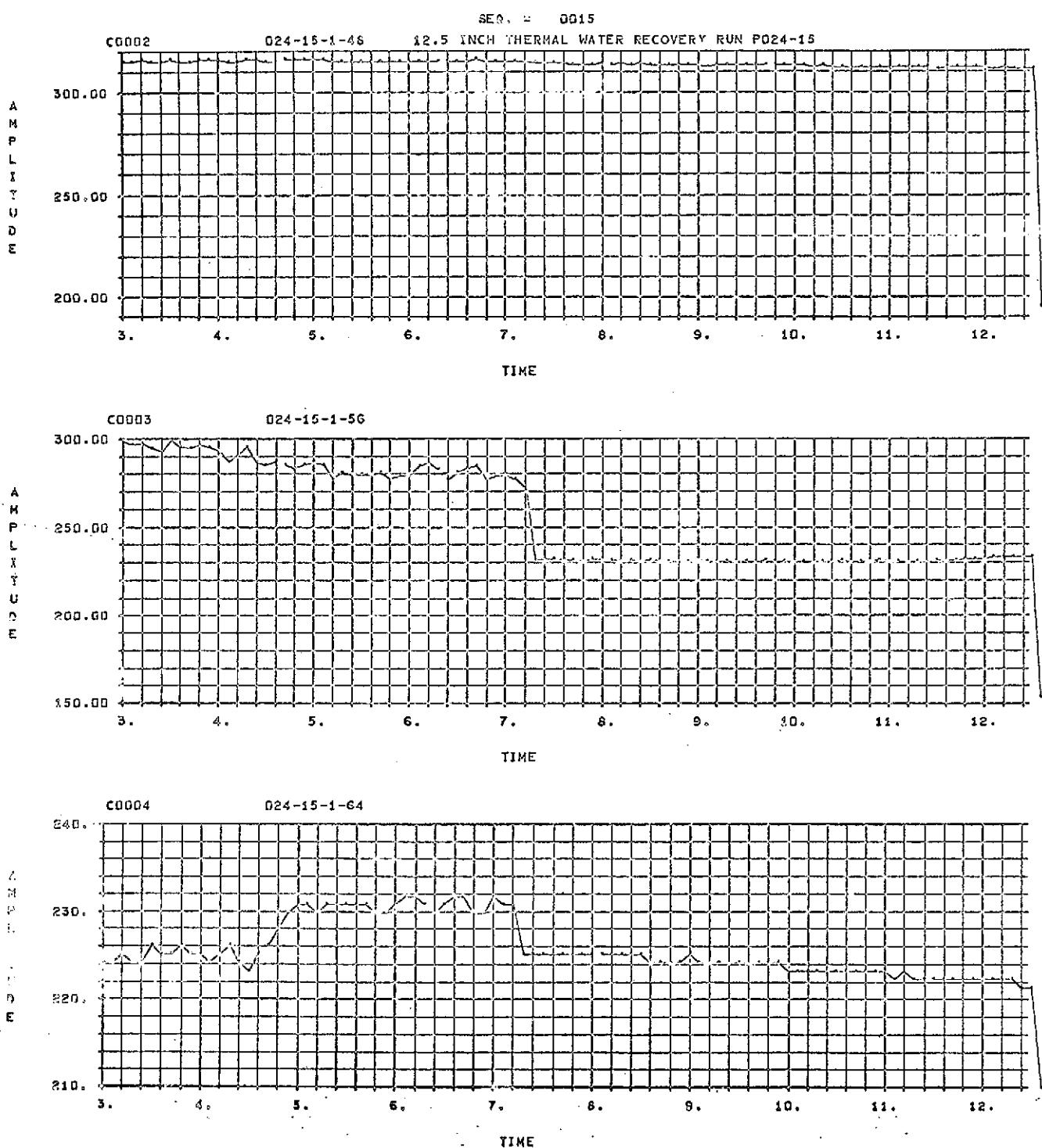
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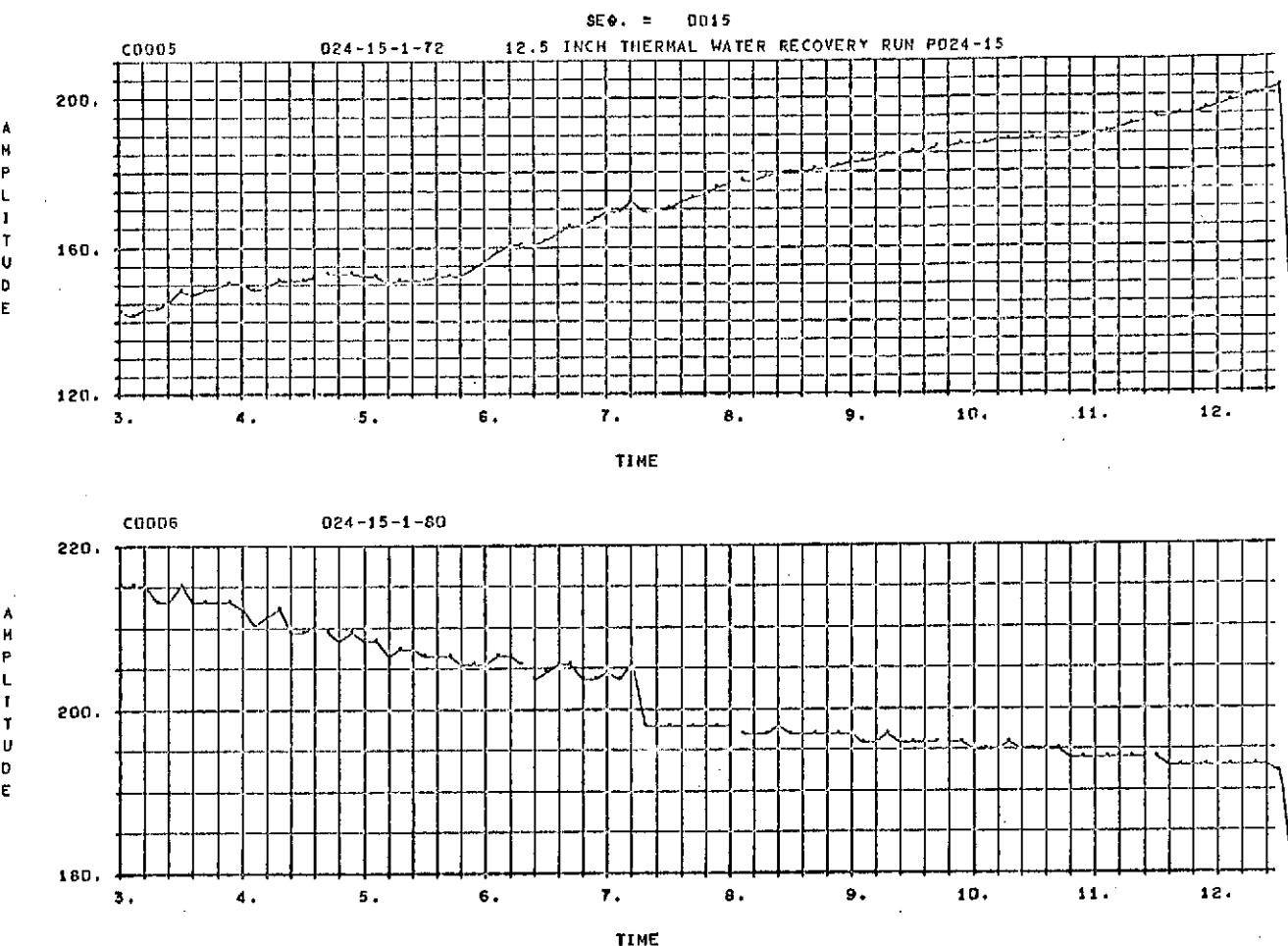


R-118

SEQ. = D015

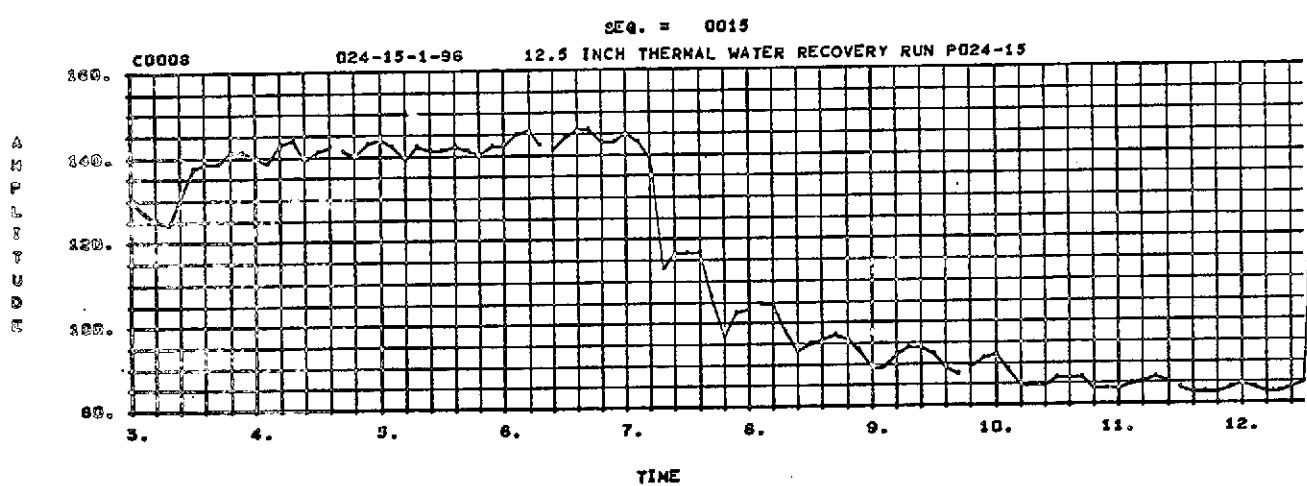
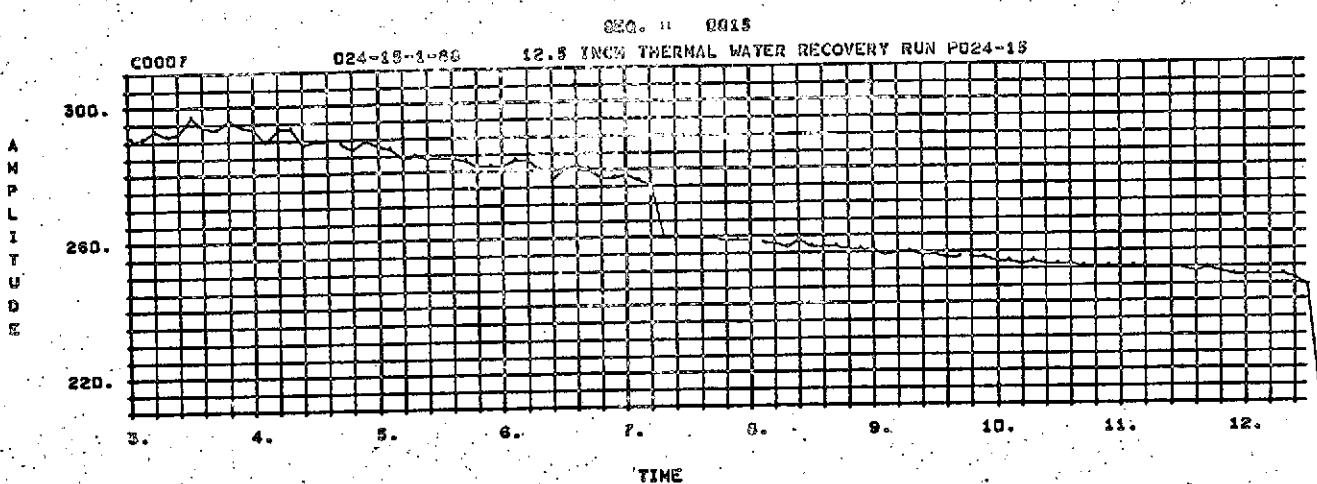




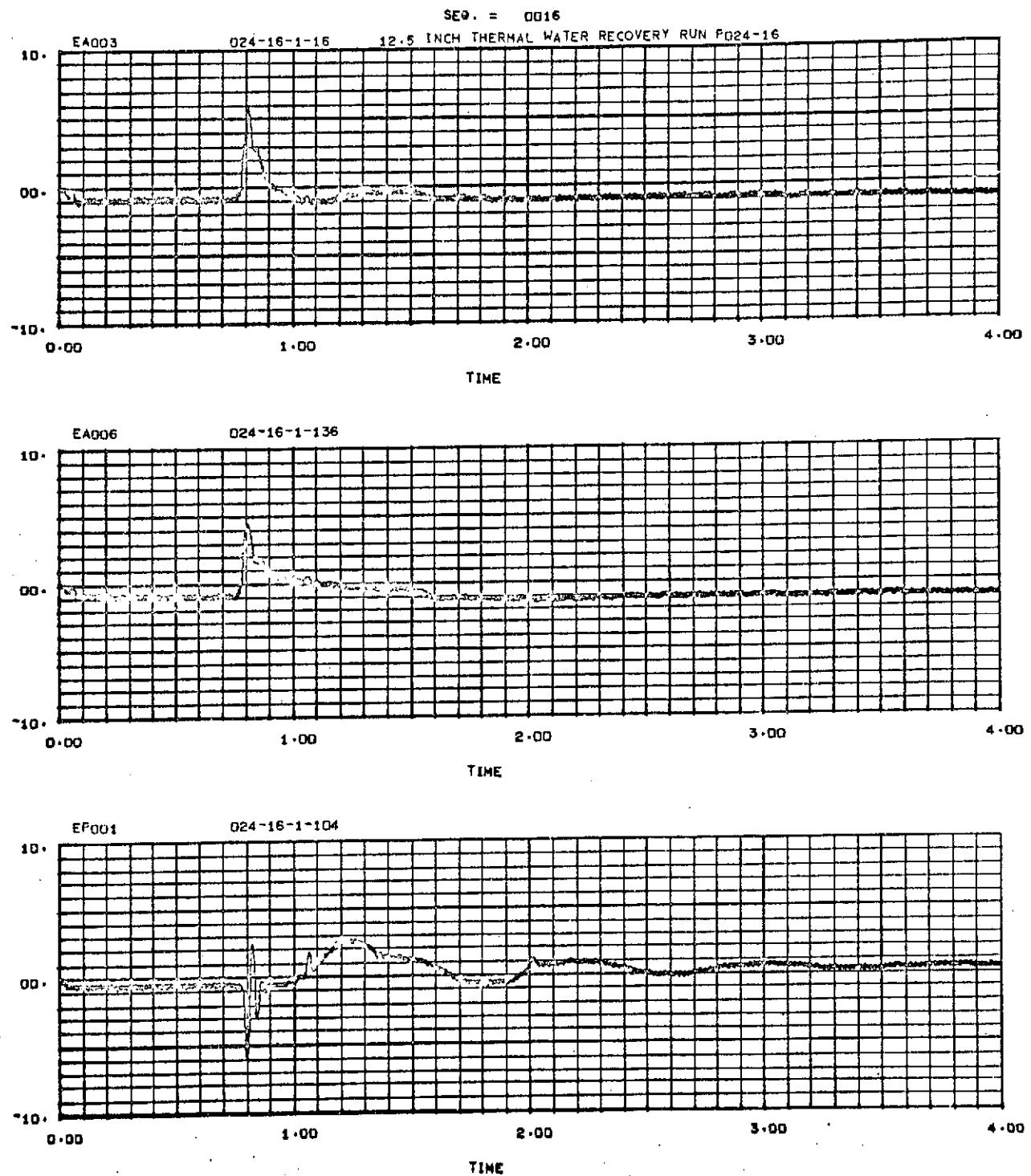


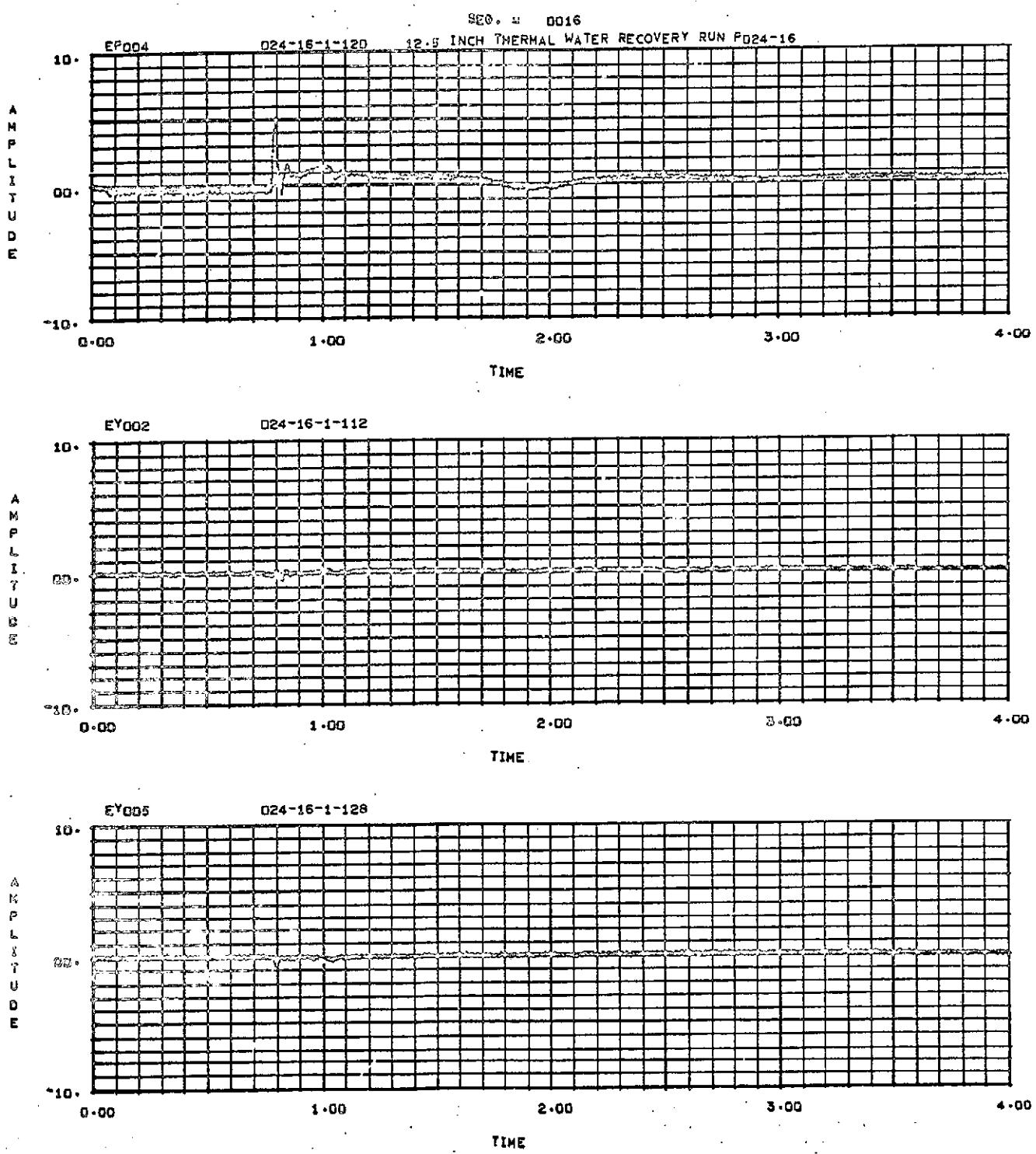
B-121

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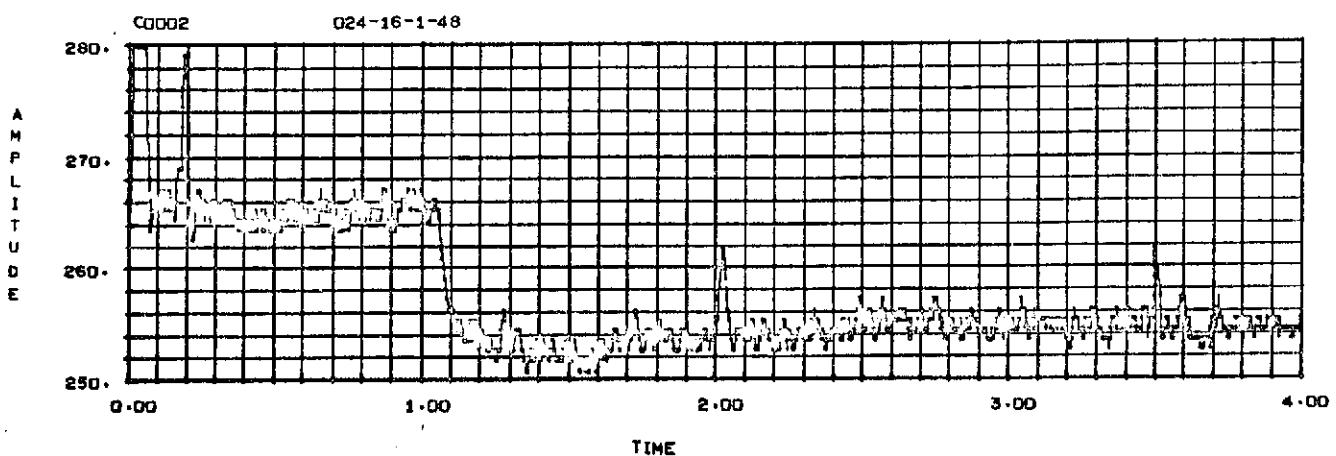
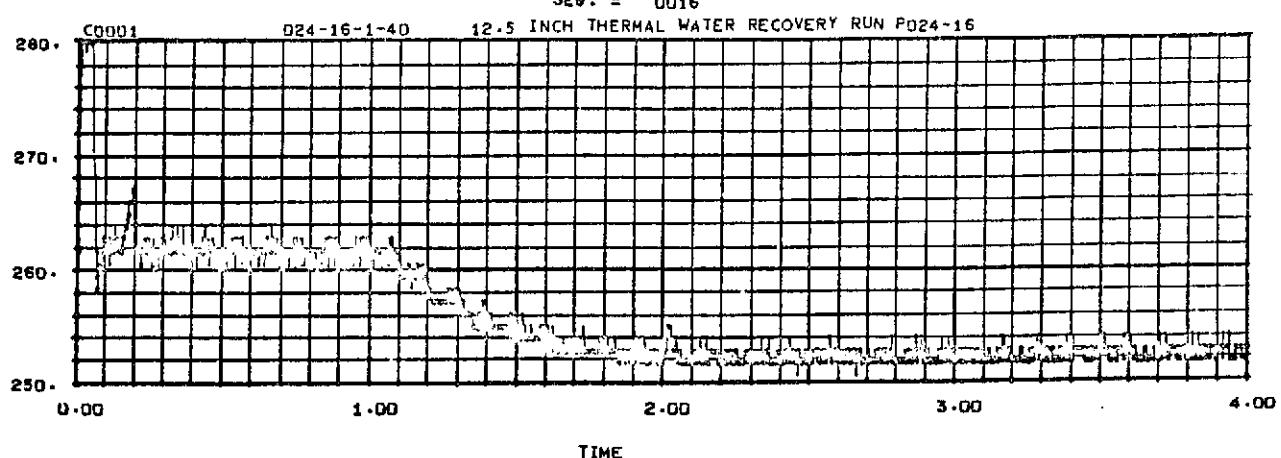
B-122



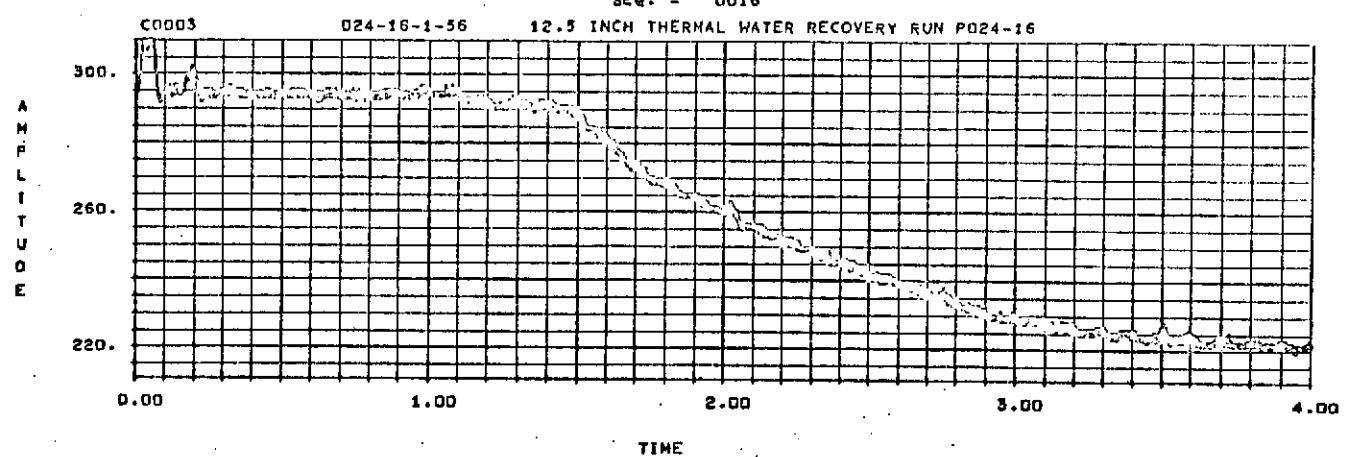


B-124

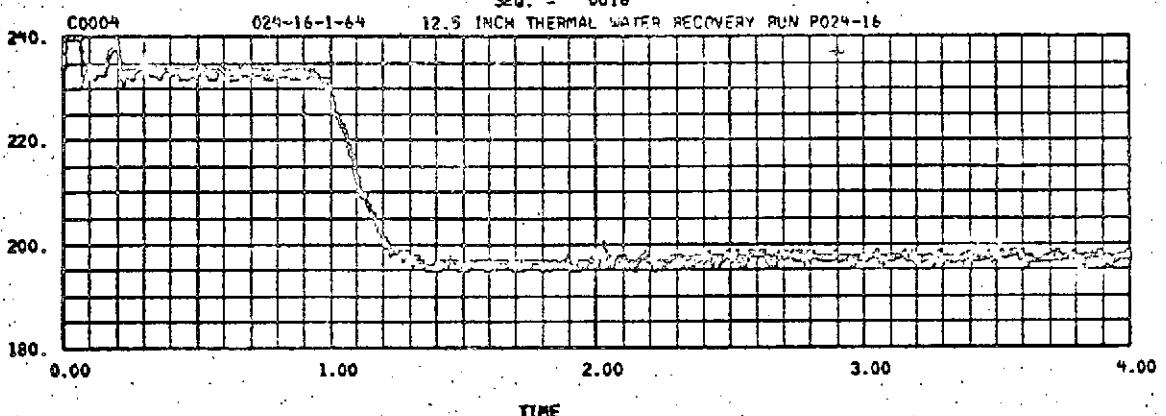
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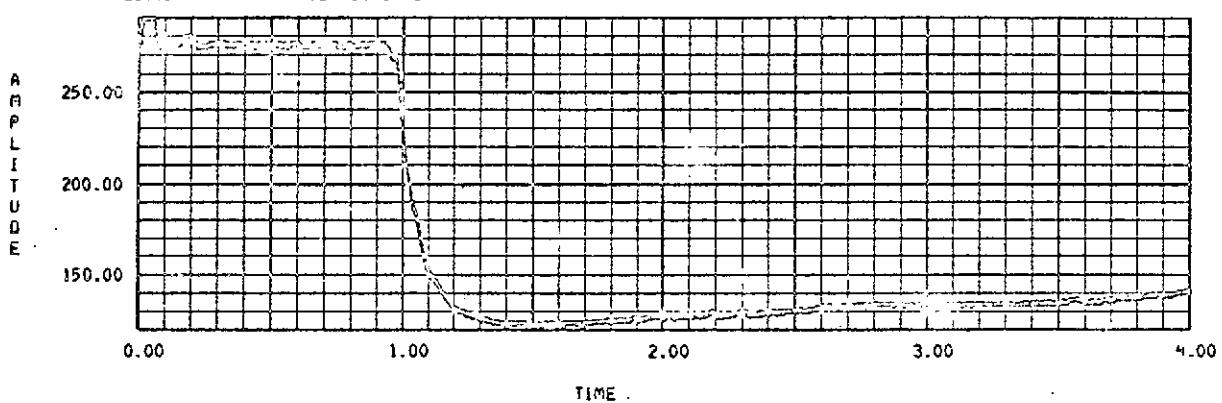
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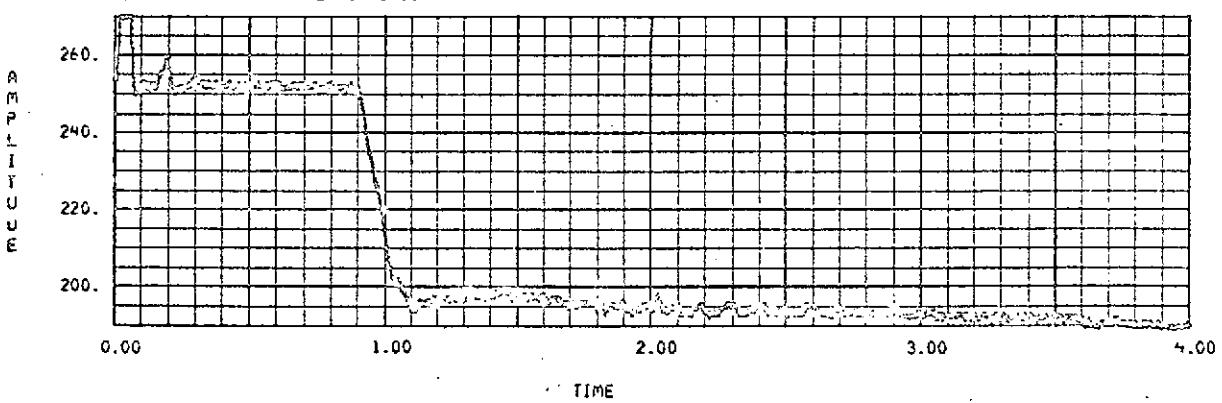
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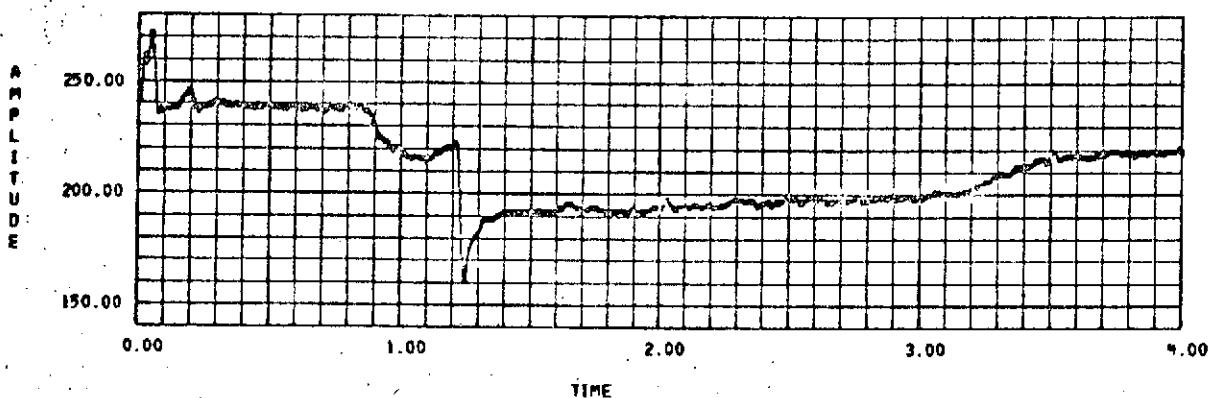
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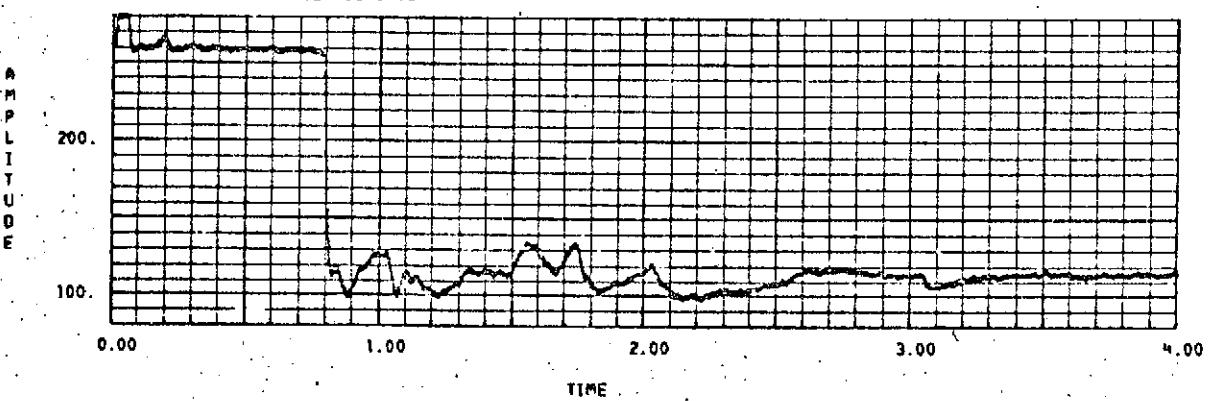
C0006 024-16-1-80



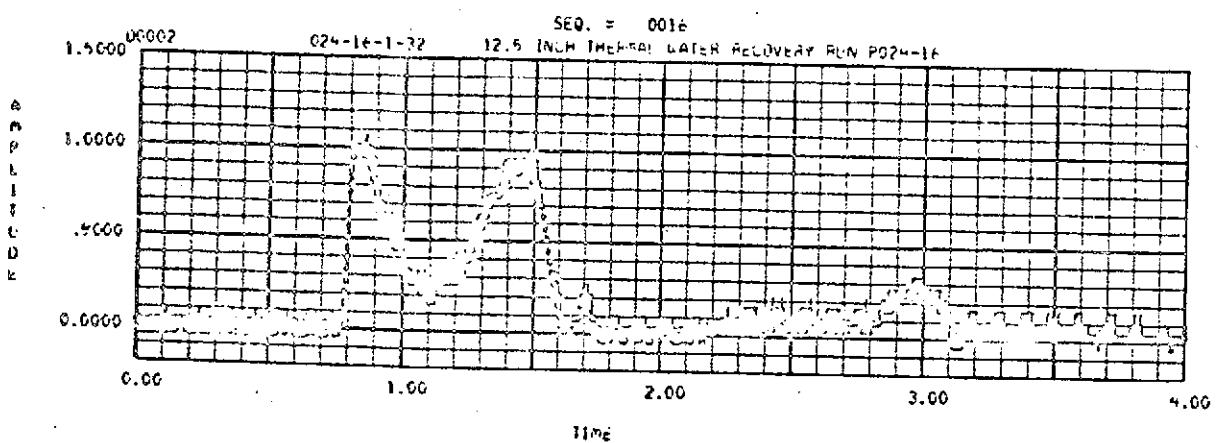
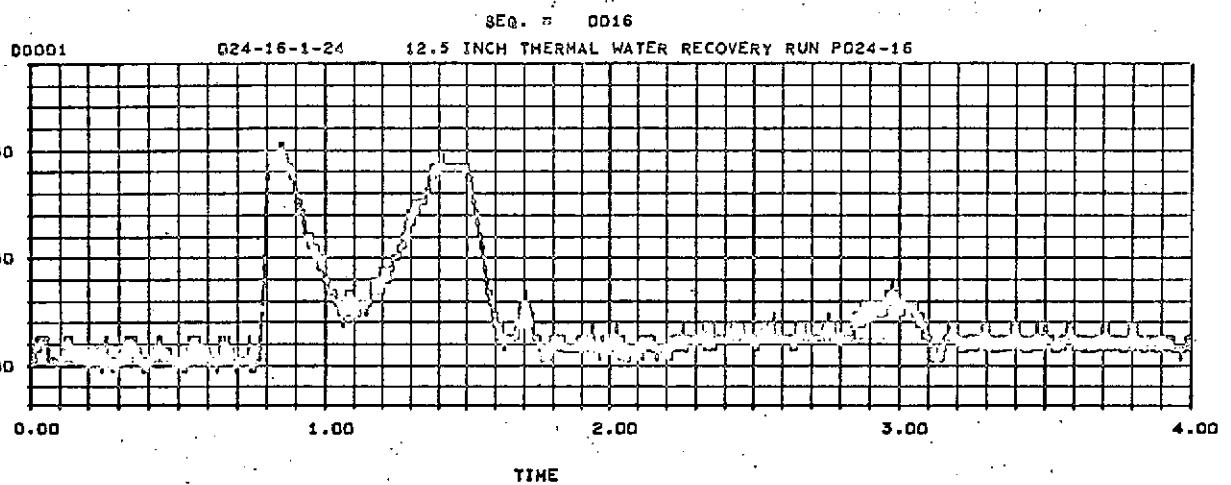
C0007 024-16-1-68



C0008 024-16-1-96

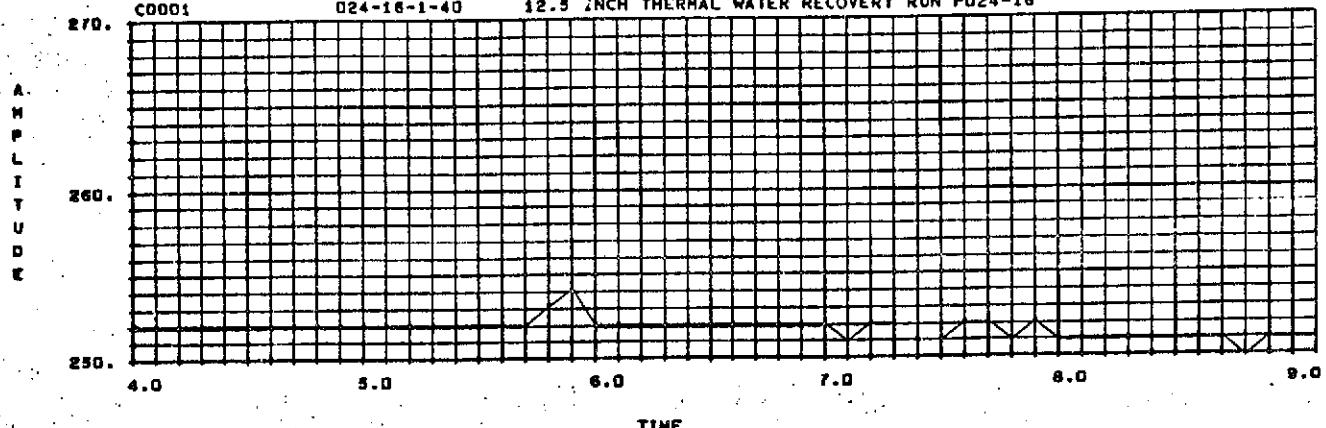


B127

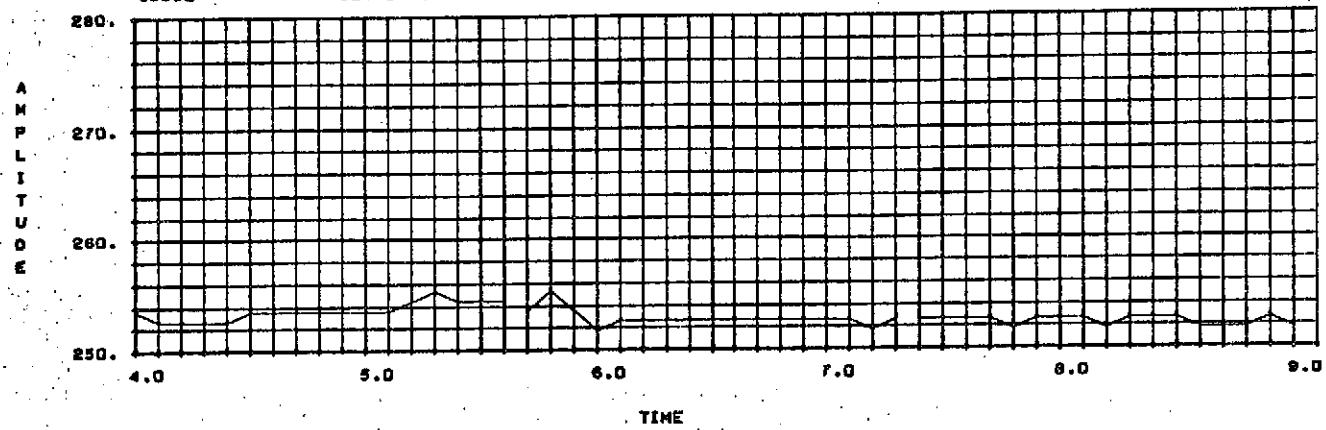


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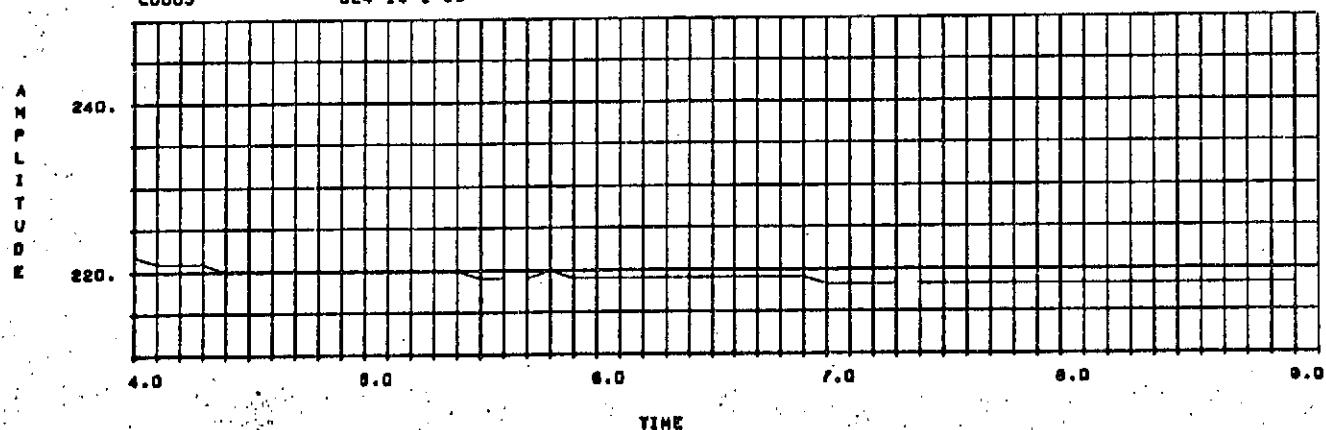
C0001 024-16-1-40 12.5 INCH THERMAL WATER RECOVERY RUN P024-16



C0002 024-16-1-48

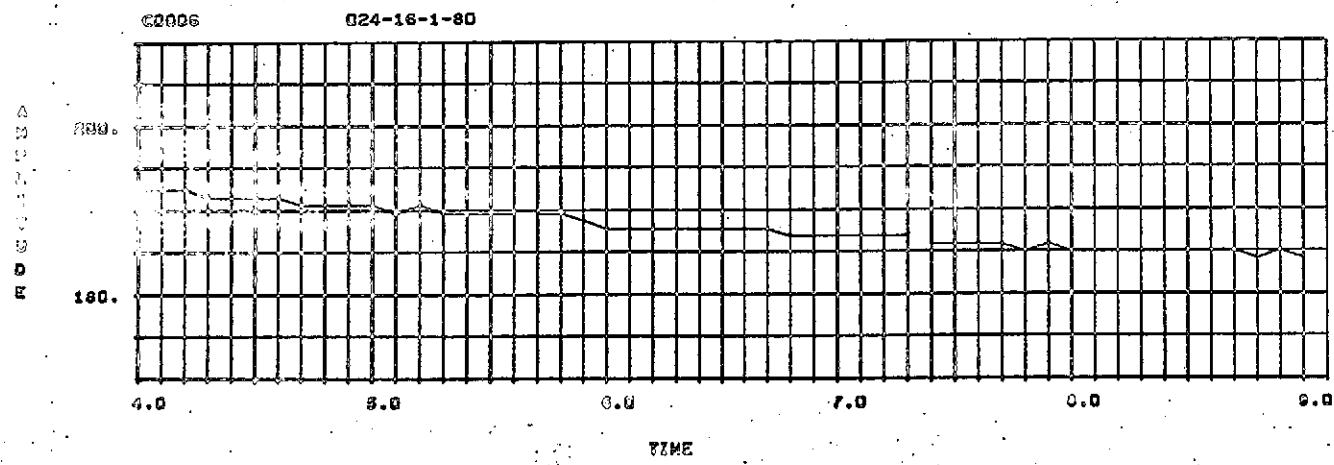
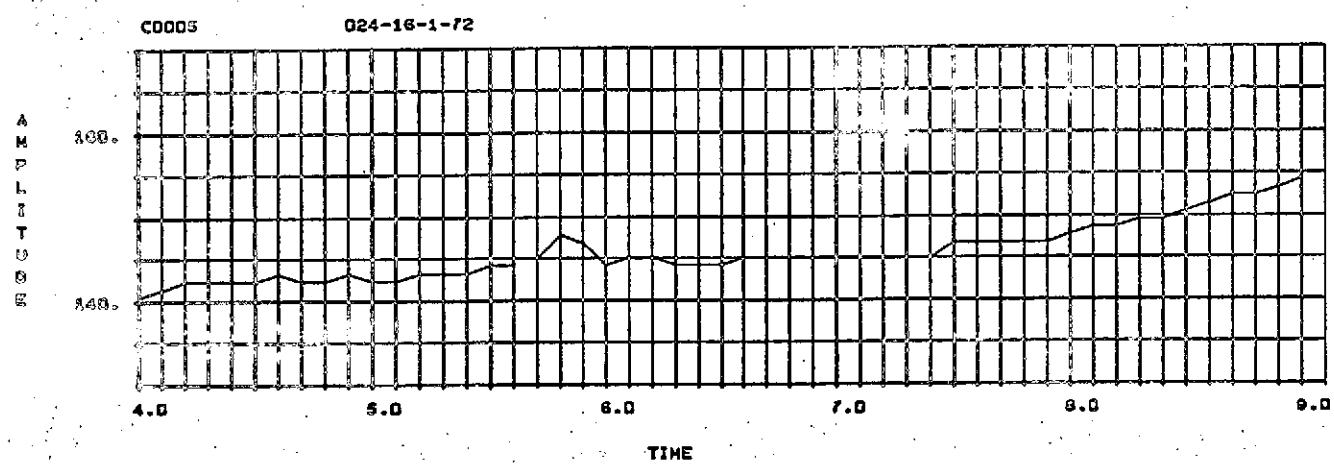
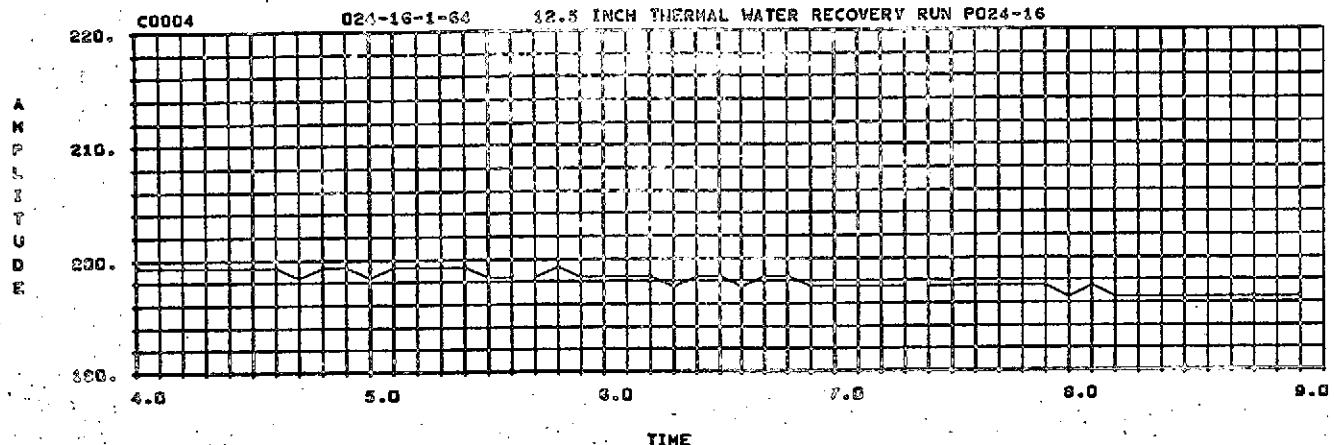


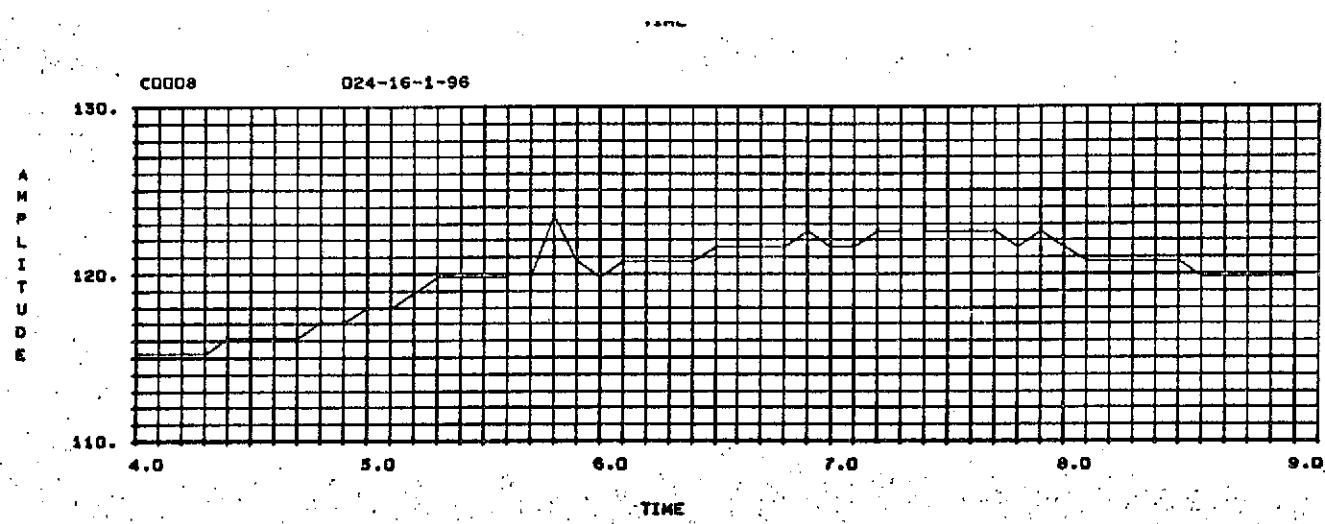
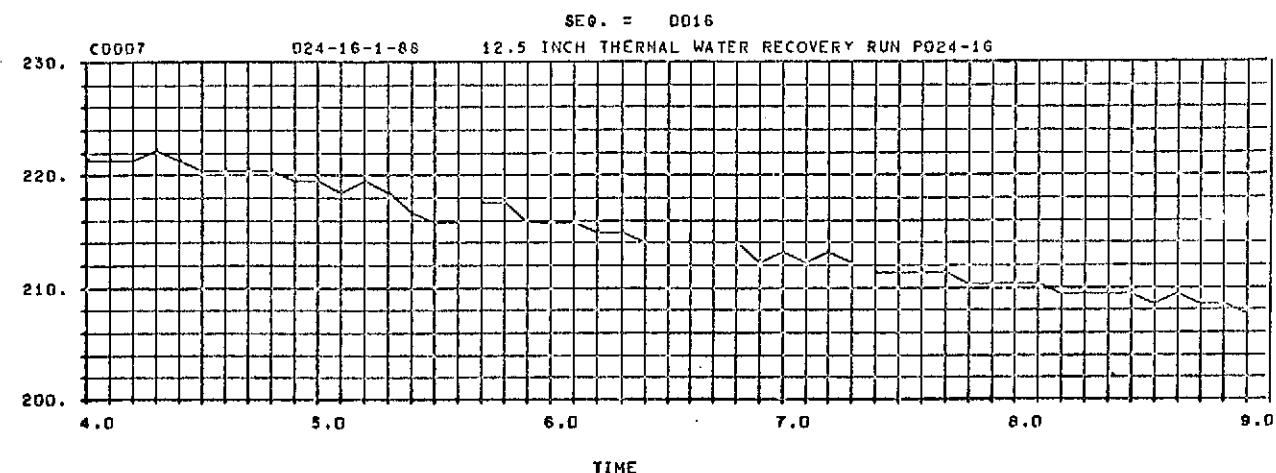
C0003 024-16-1-56

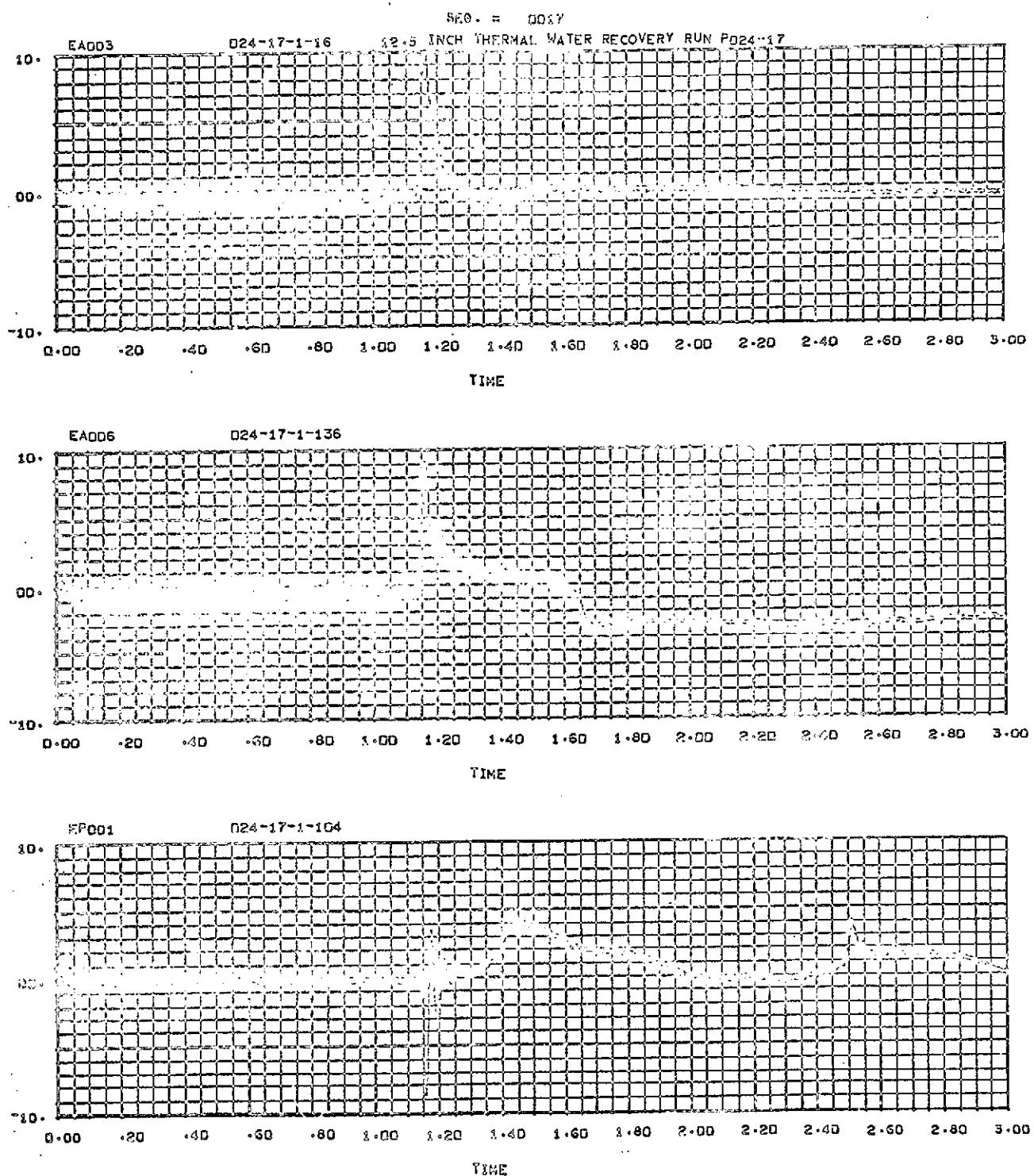


SKG. # 3840

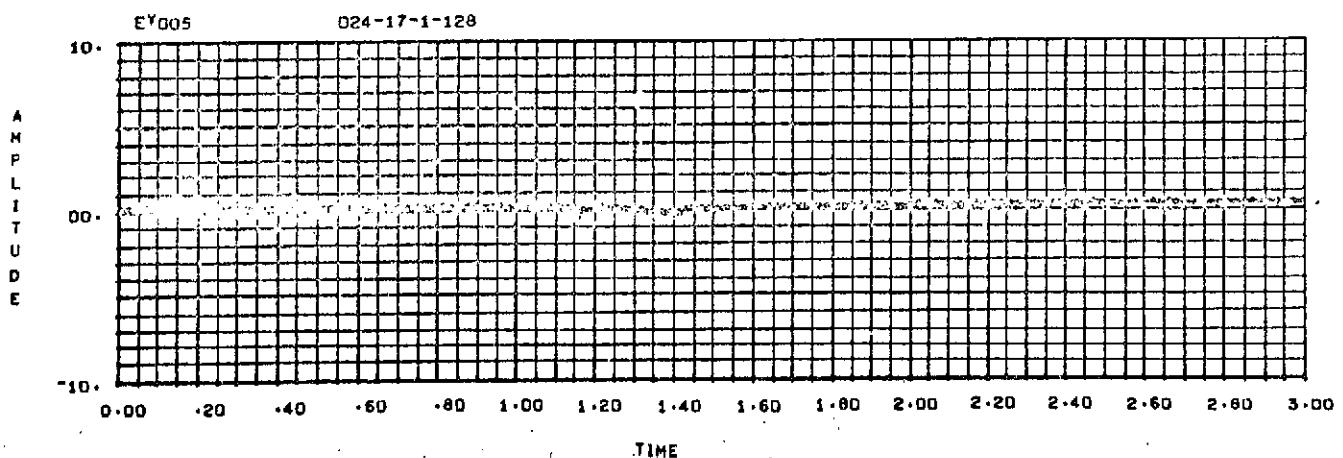
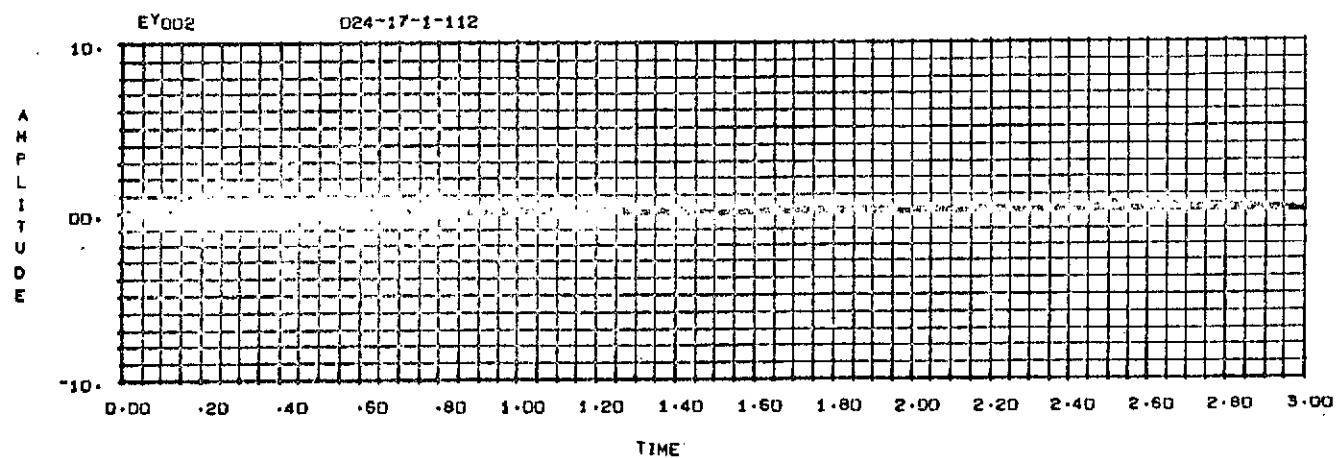
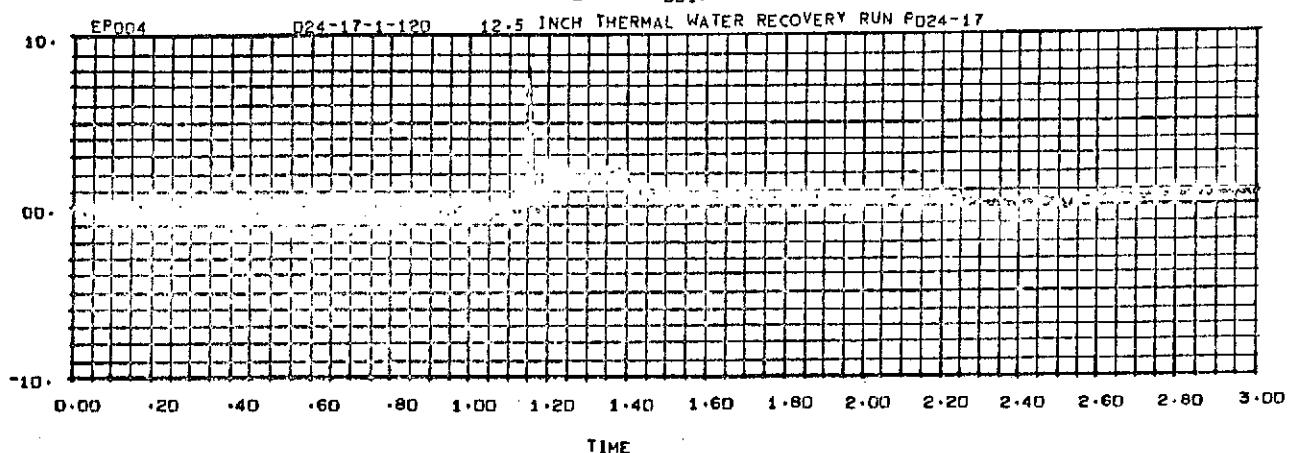
024-16-1-64 12.5 INCH THERMAL WATER RECOVERY RUN P024-16



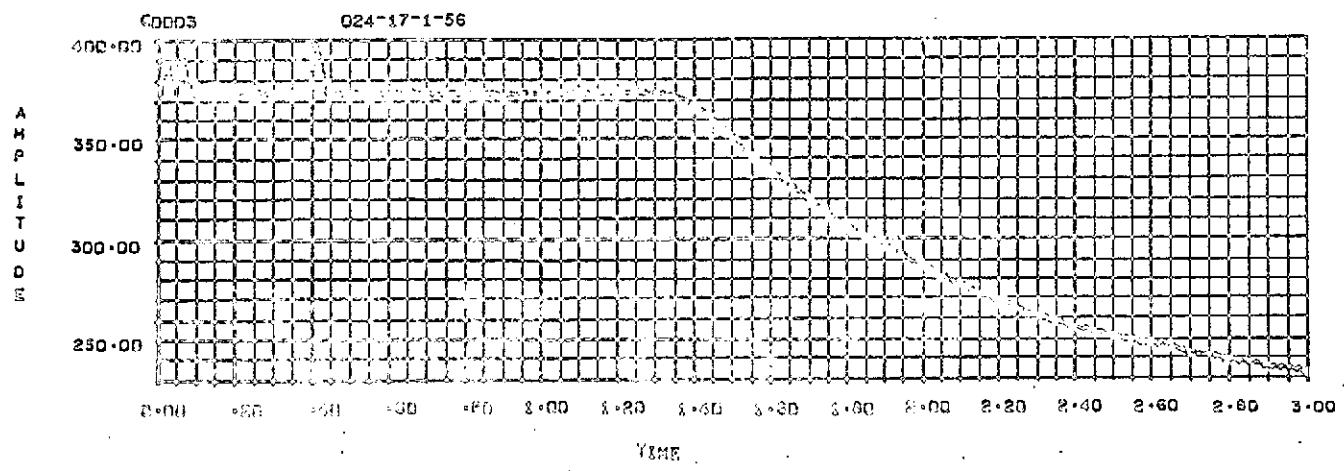
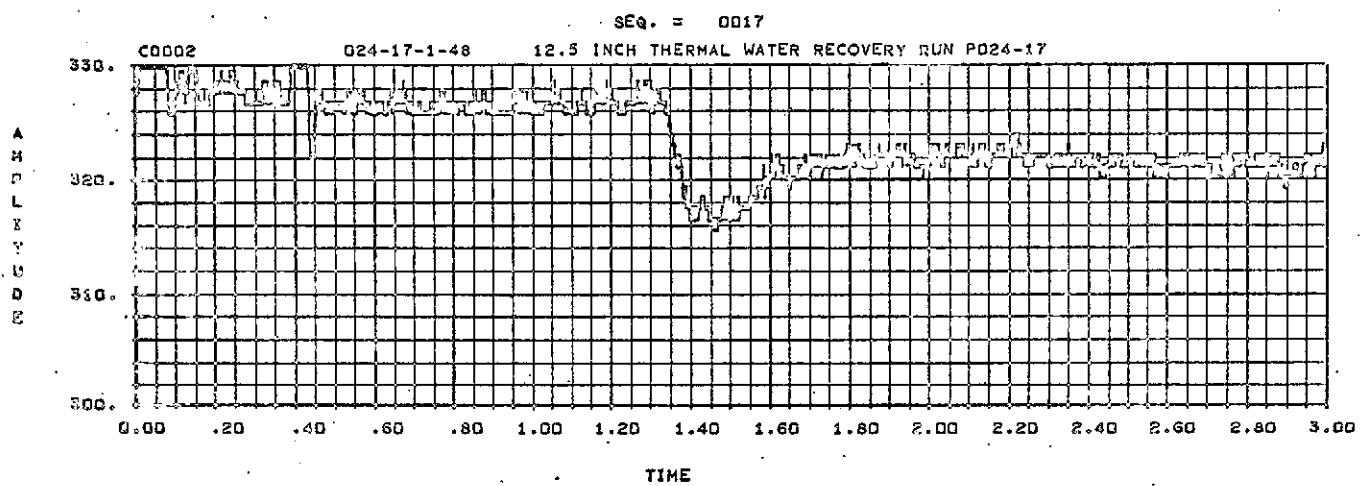
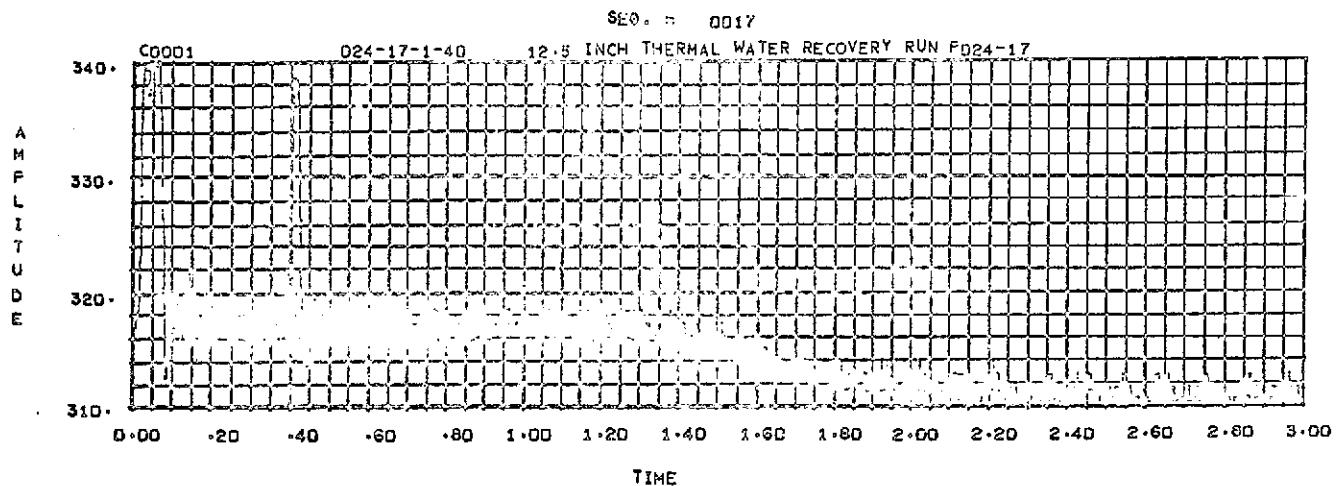


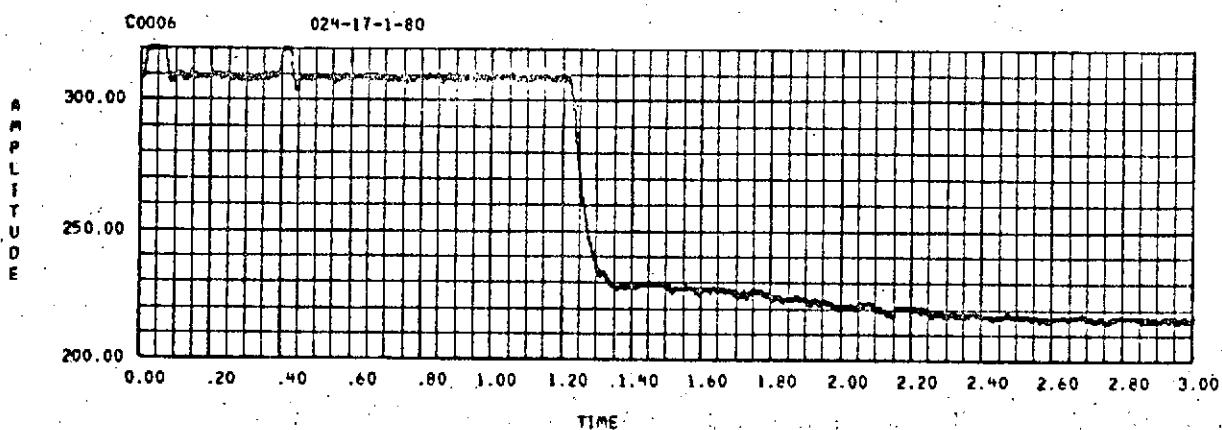
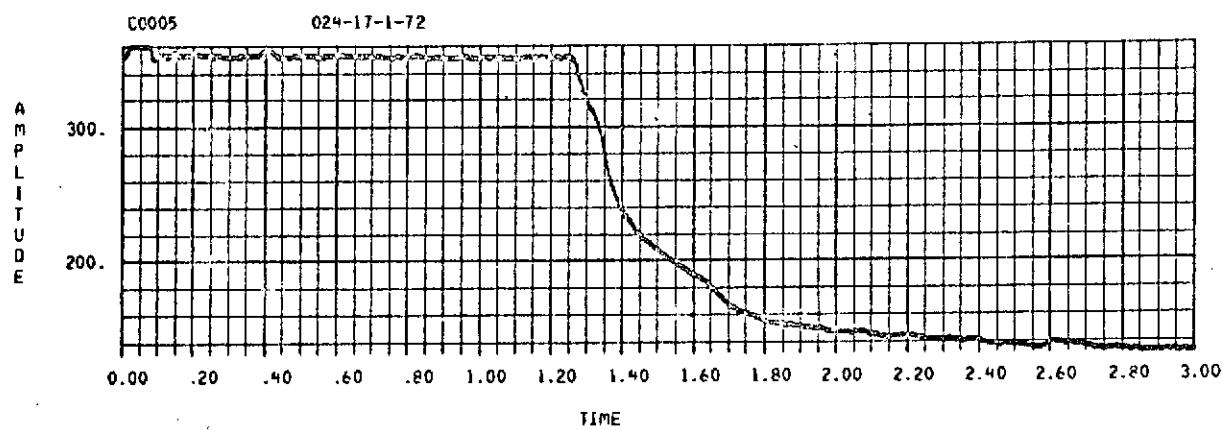
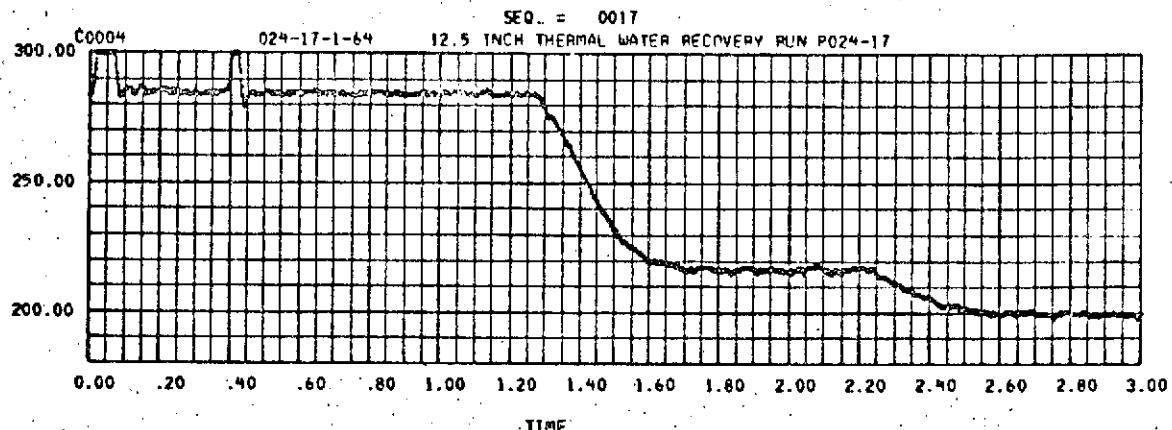


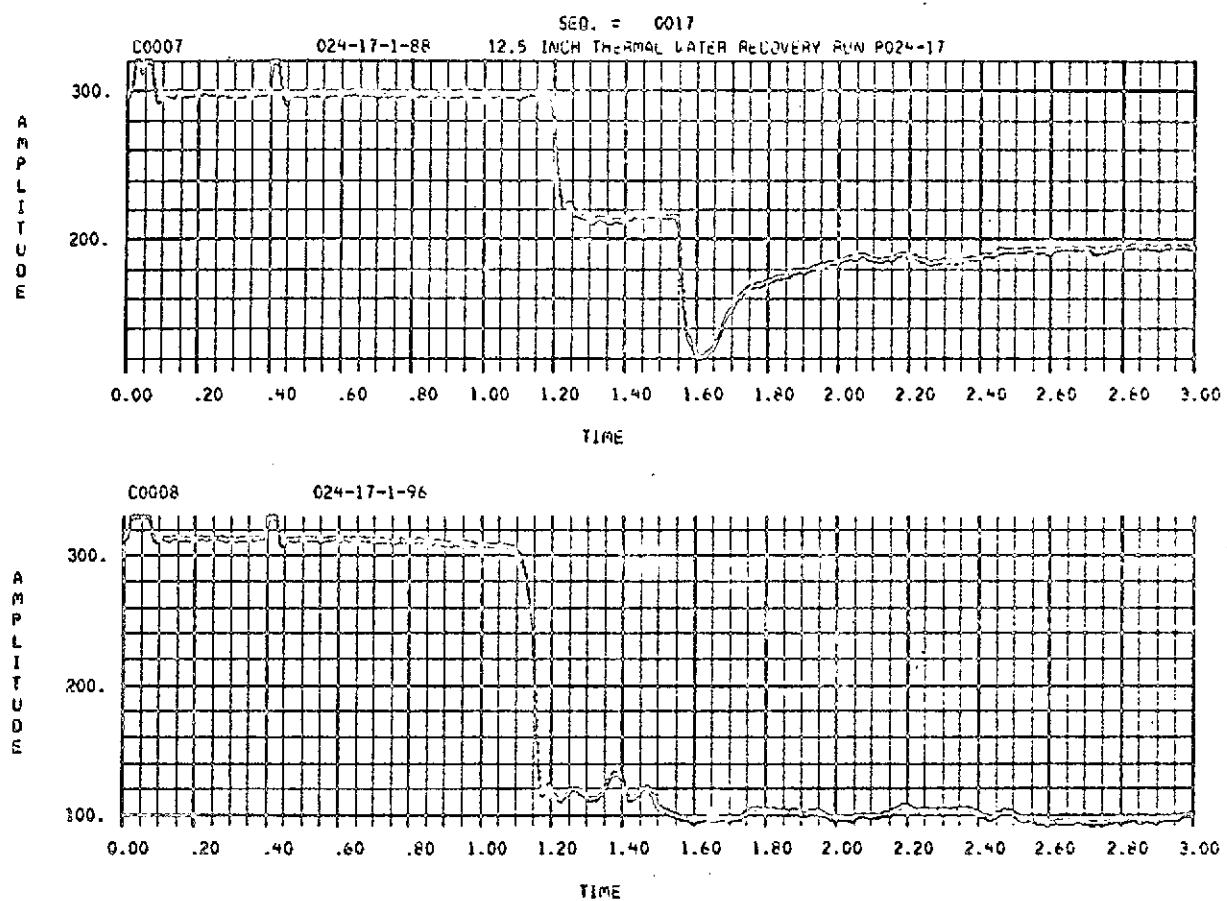
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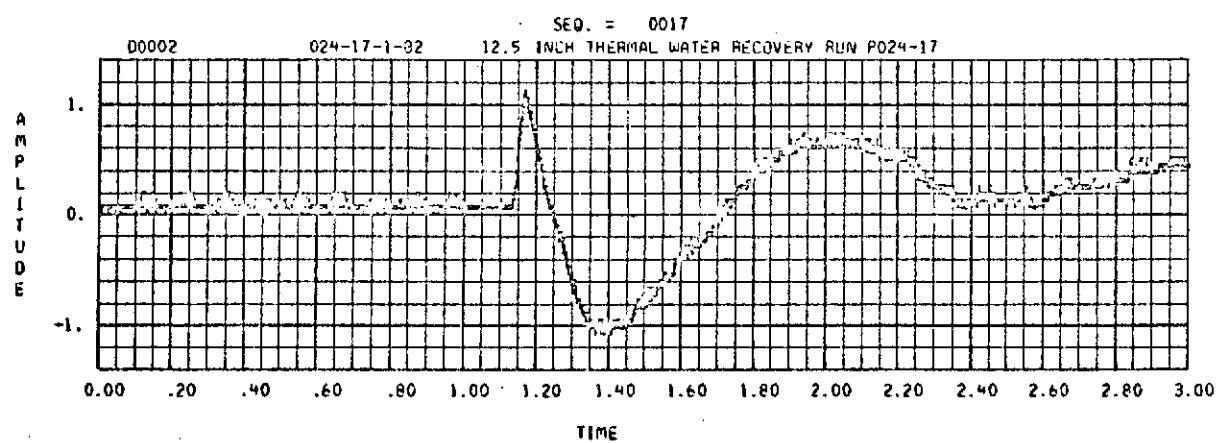
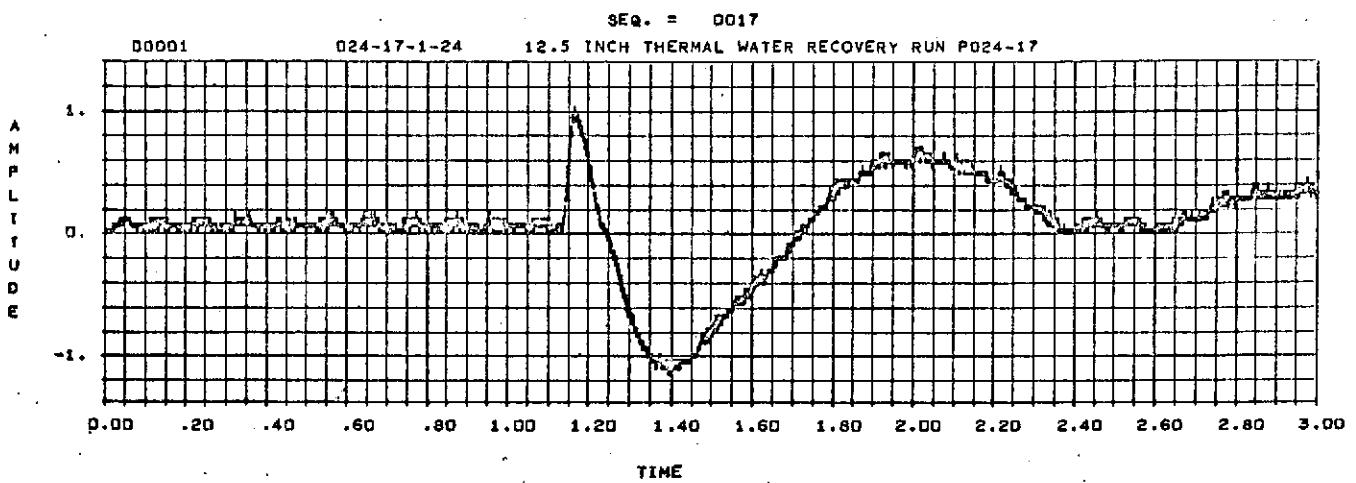


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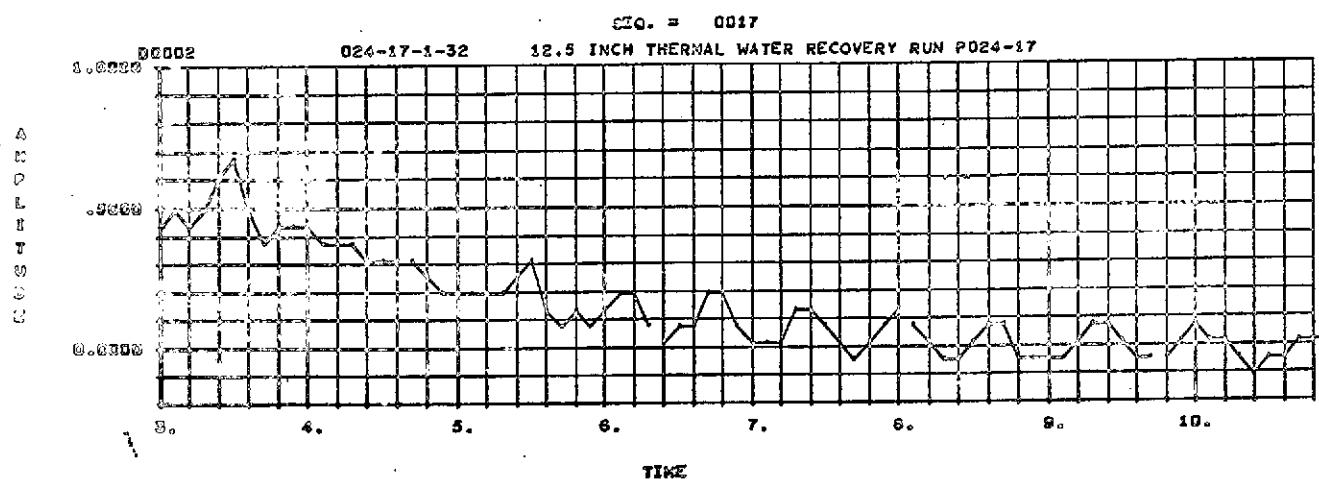
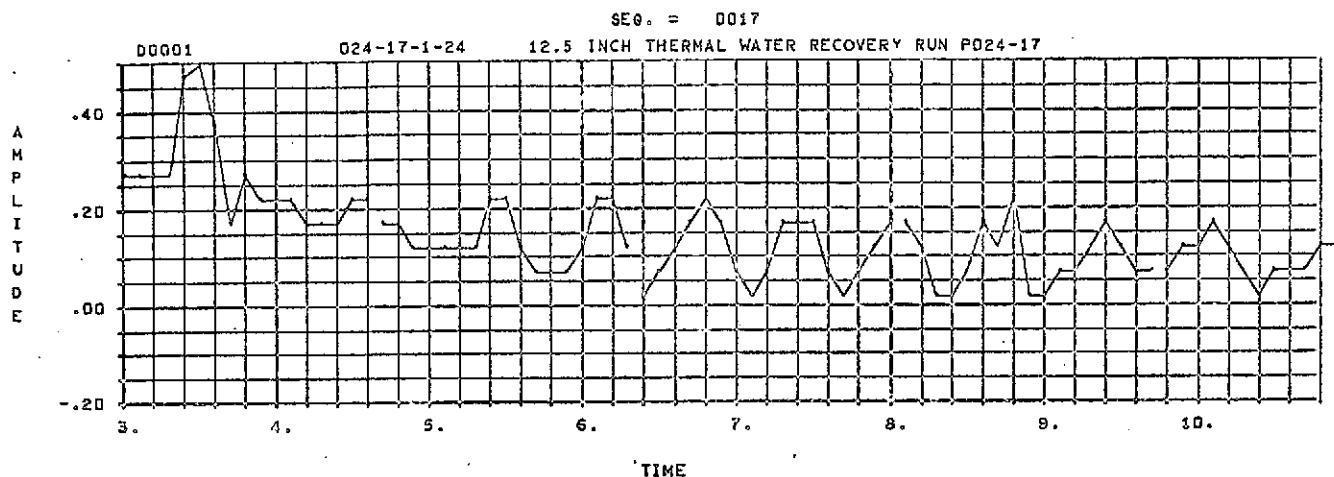


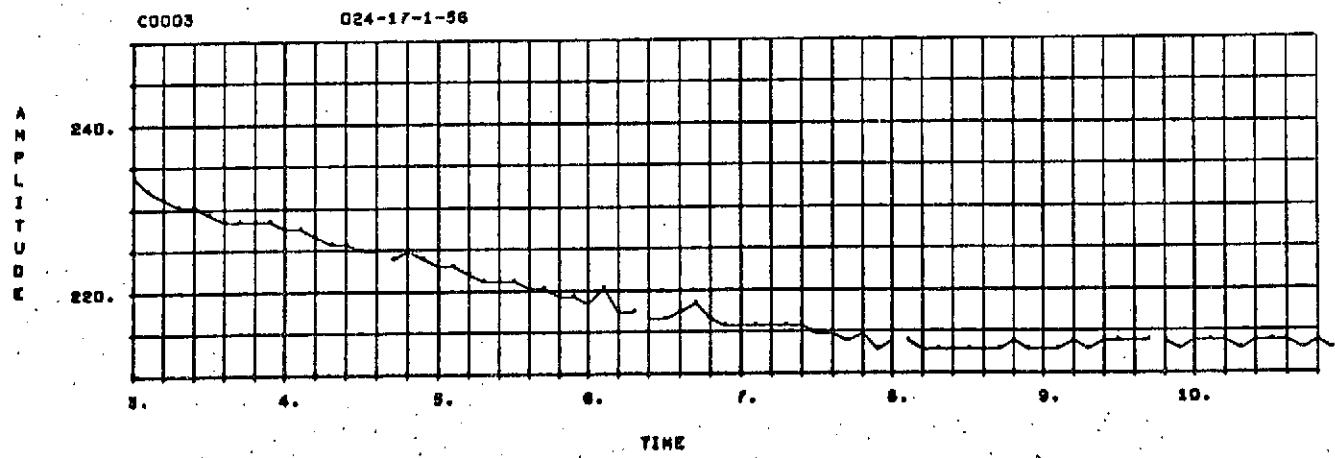
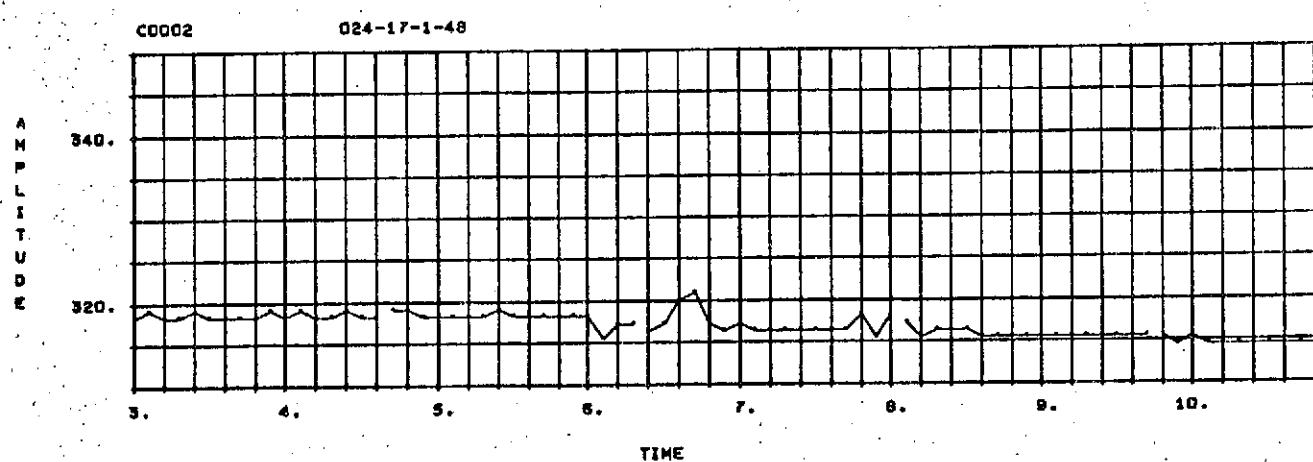
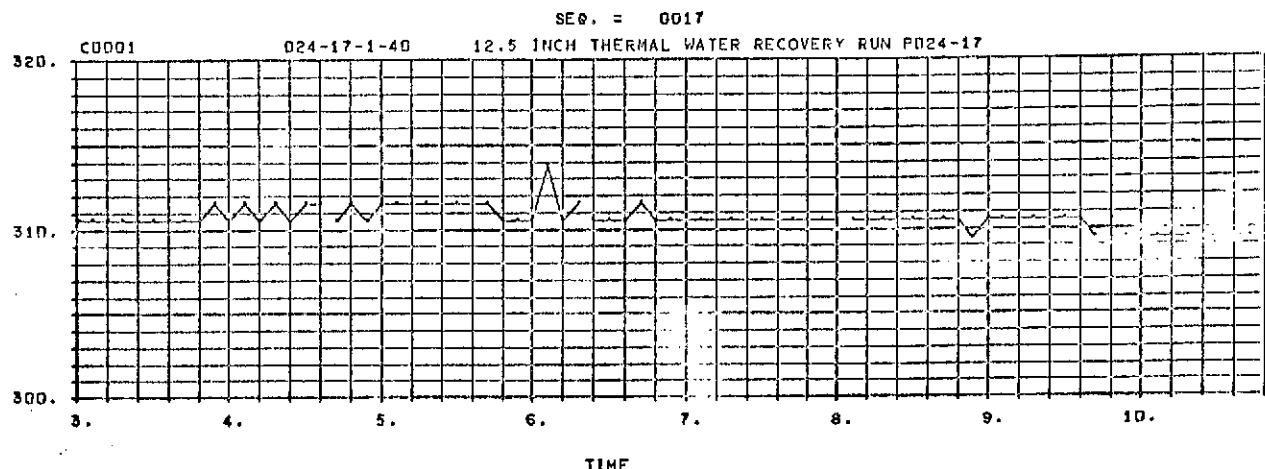






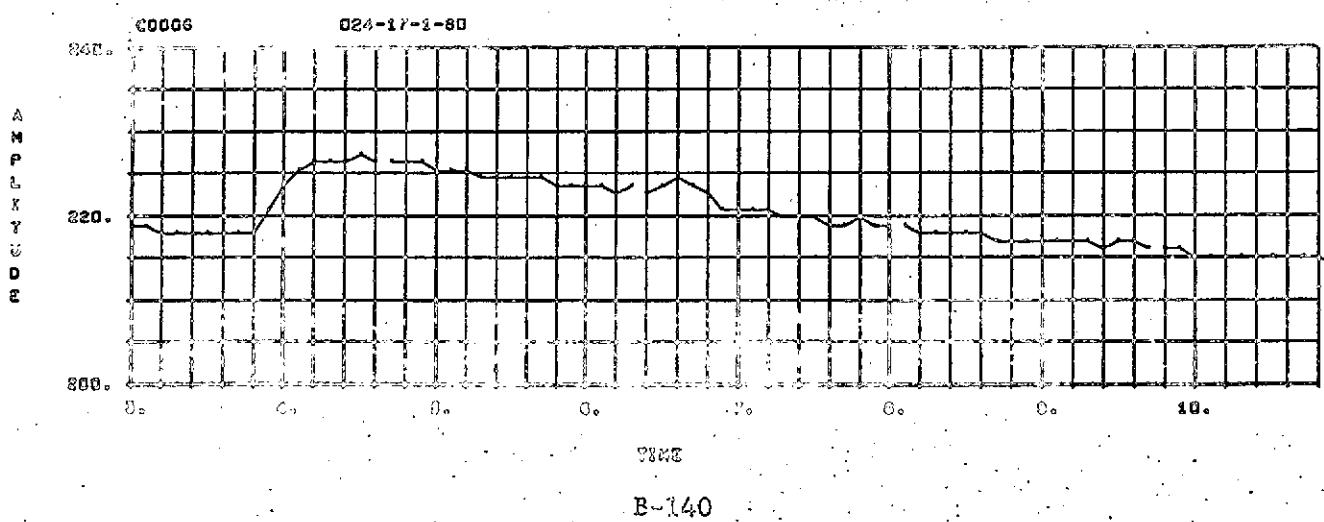
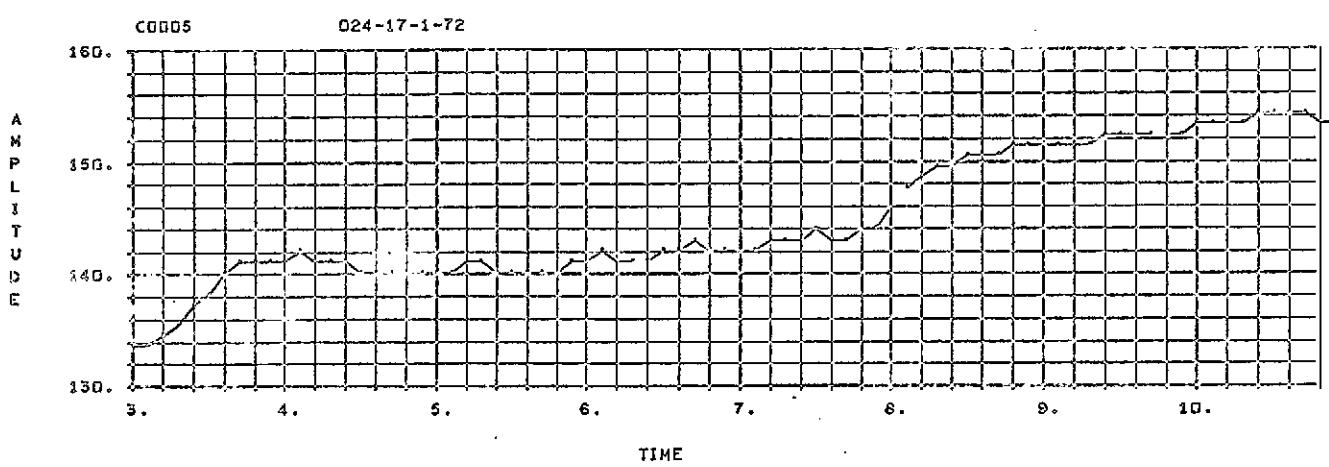
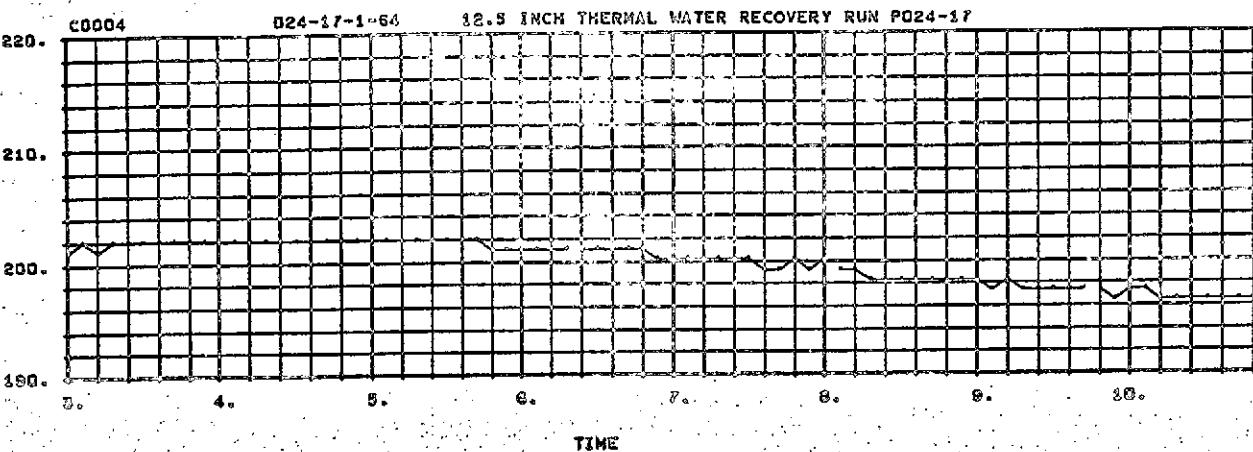
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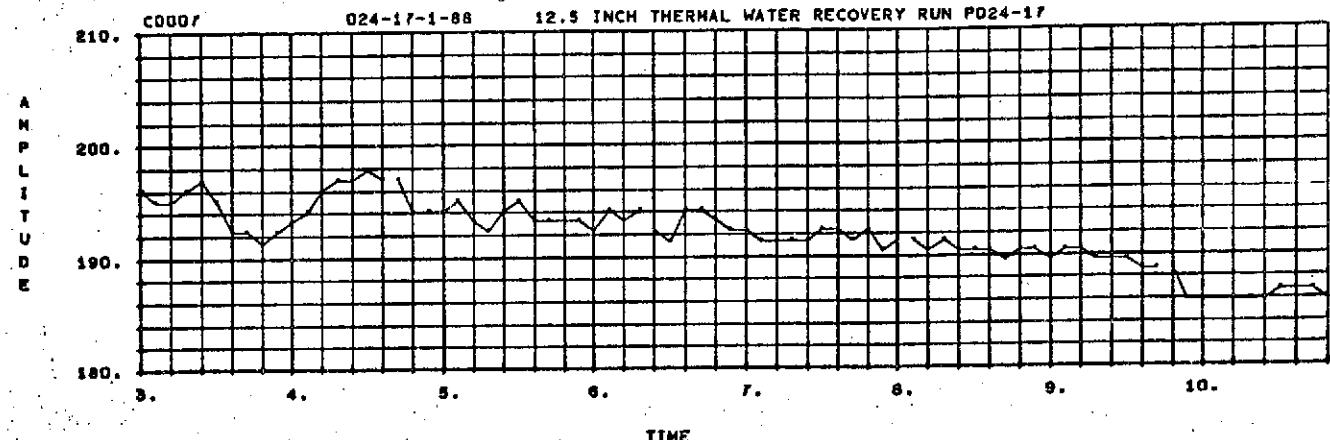
SEQ. N 8017



SEQ. = 0017

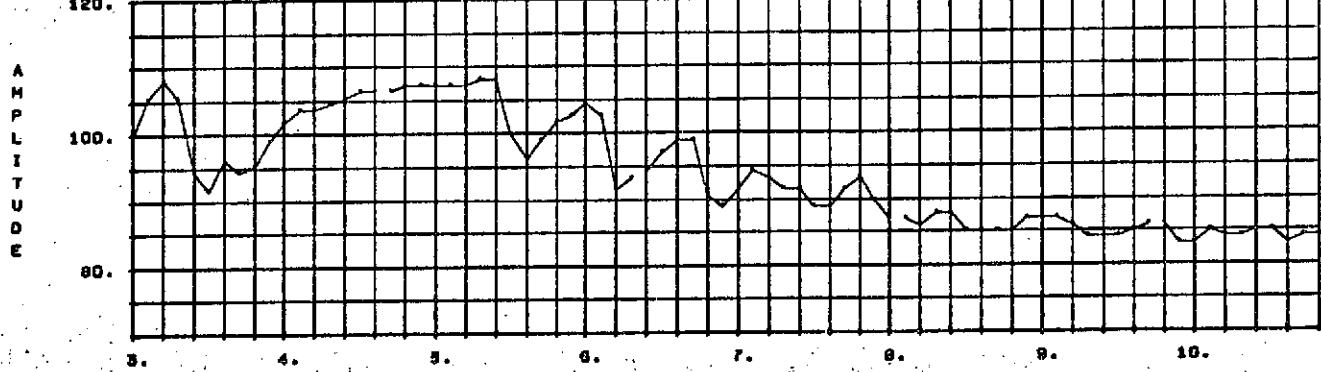
024-17-1-88

12.5 INCH THERMAL WATER RECOVERY RUN P024-17

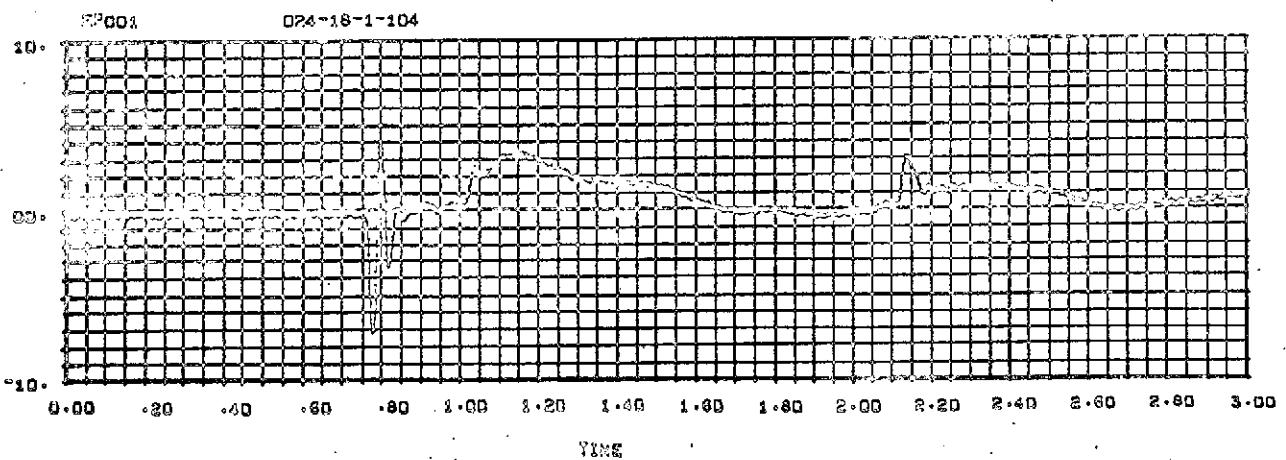
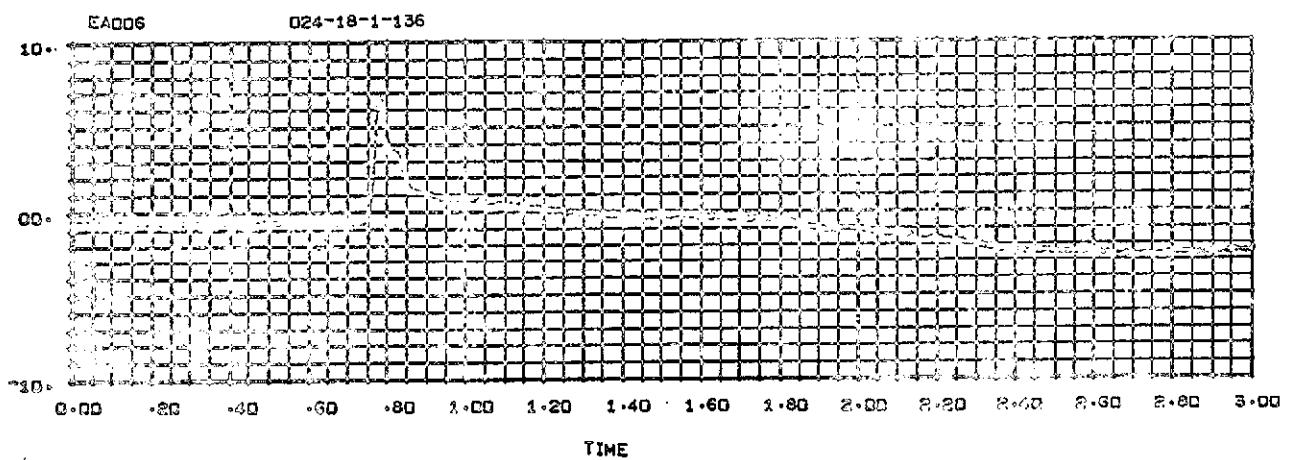
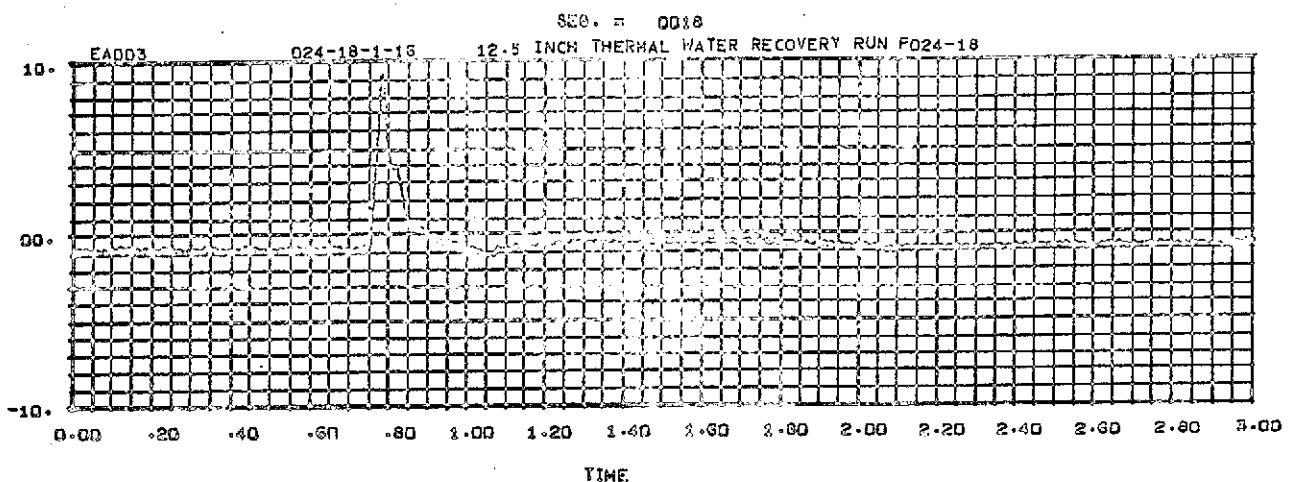


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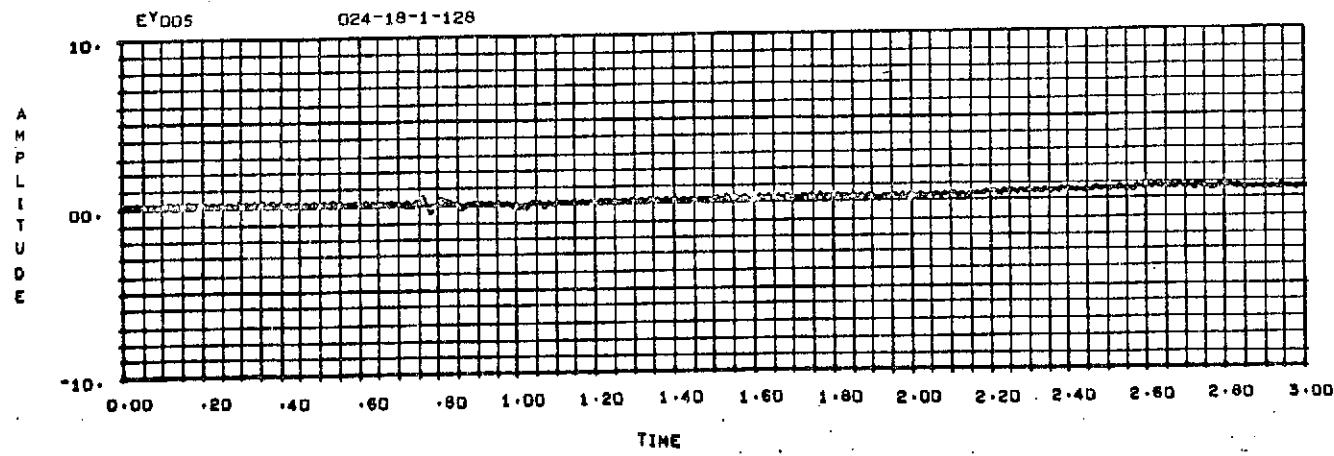
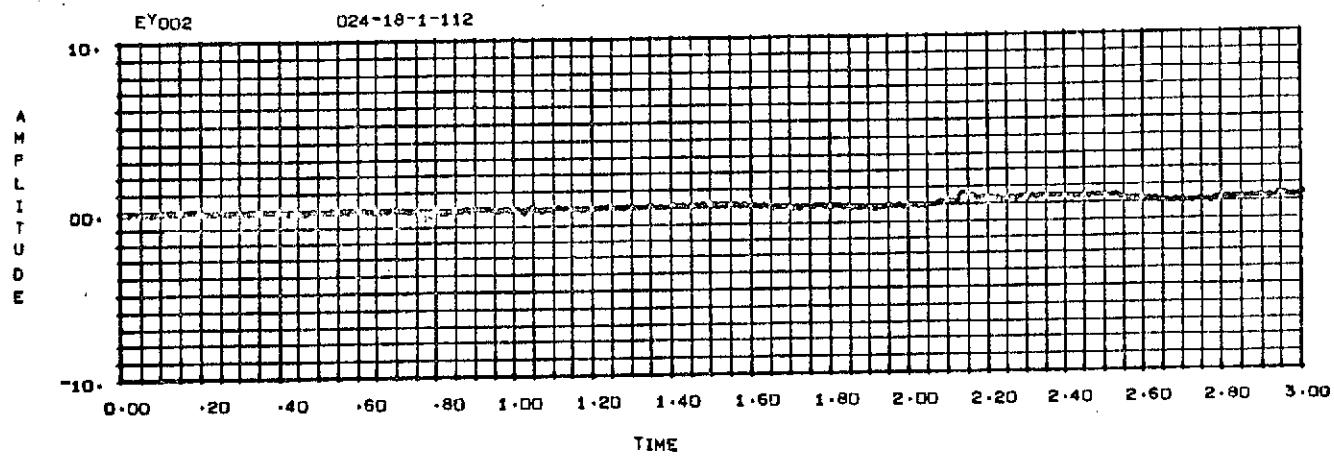
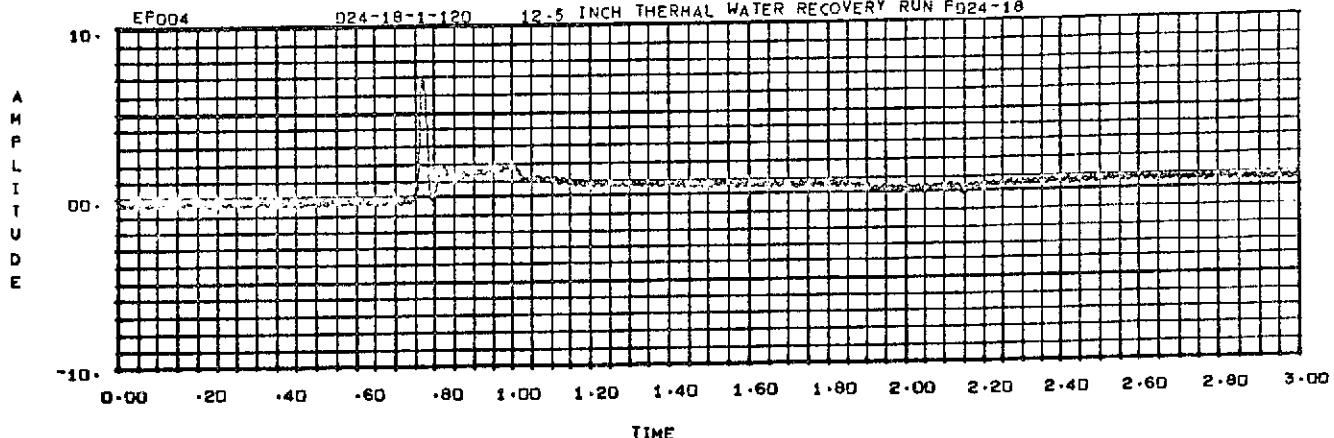


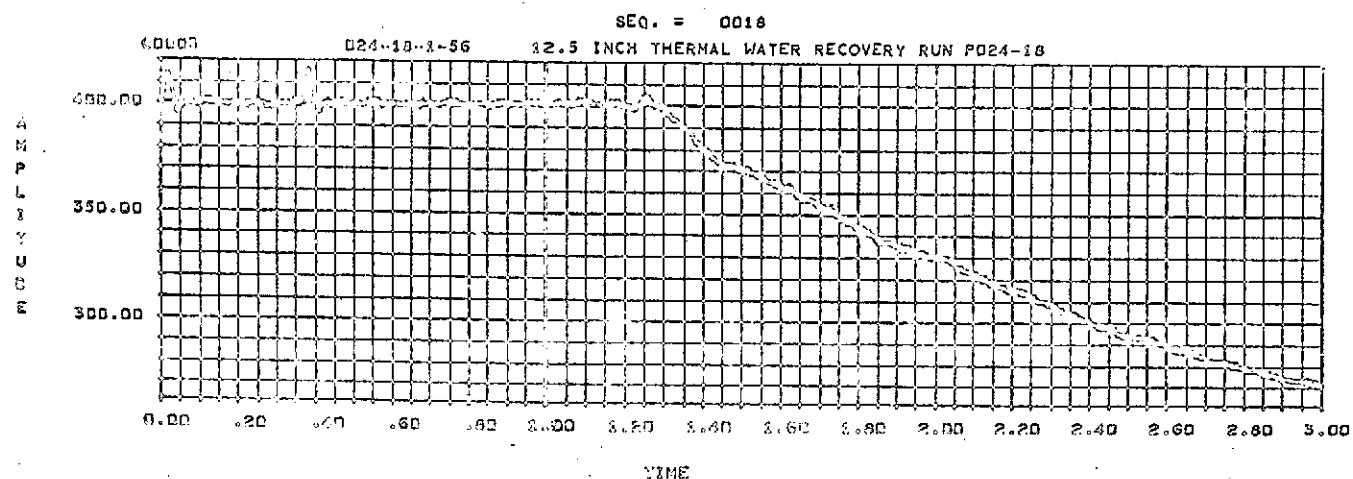
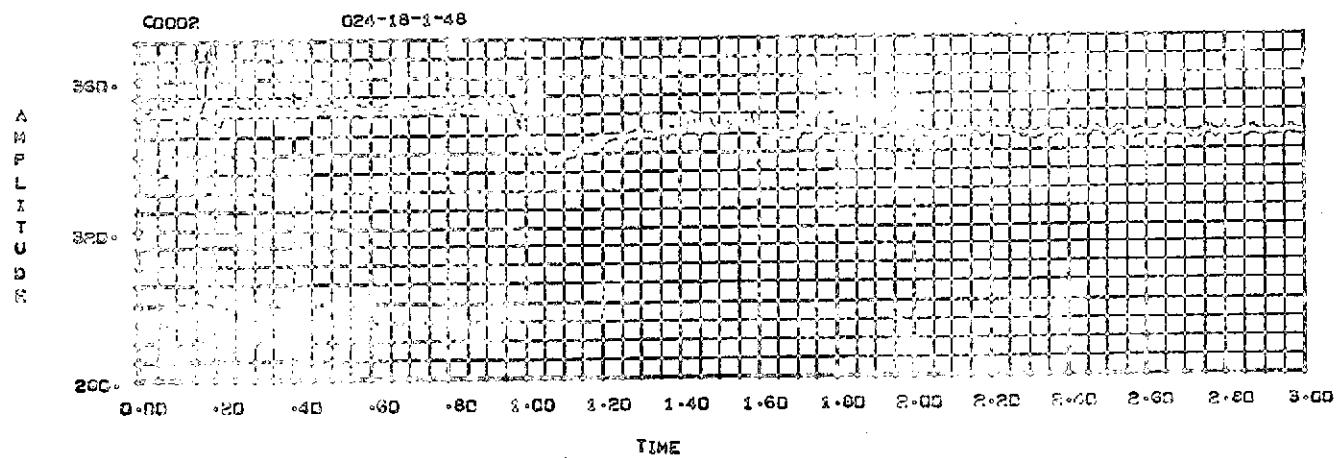
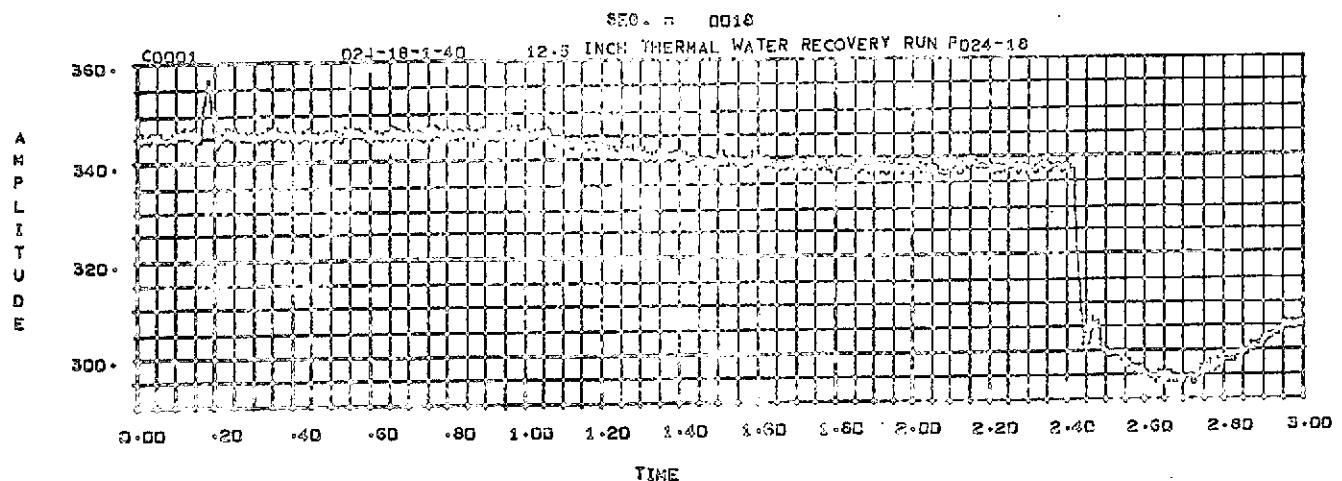
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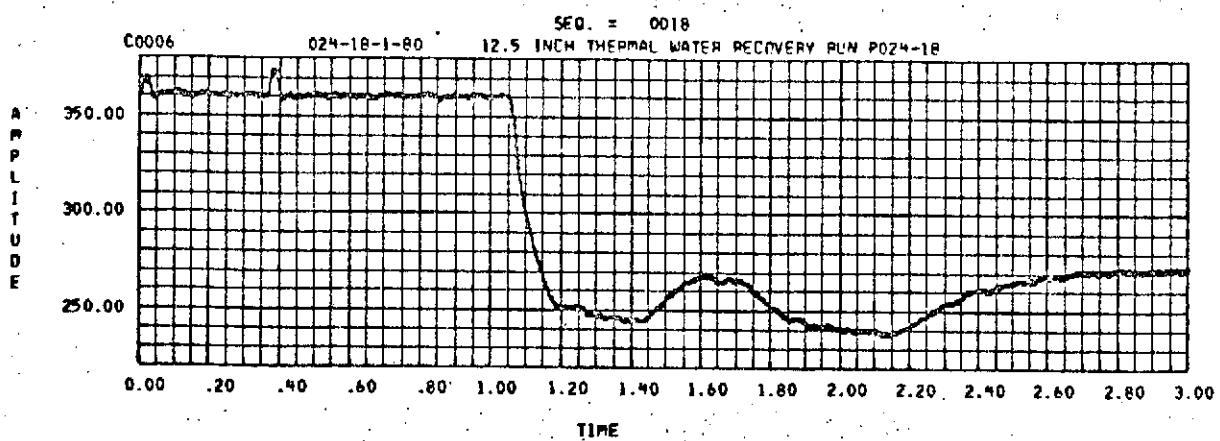
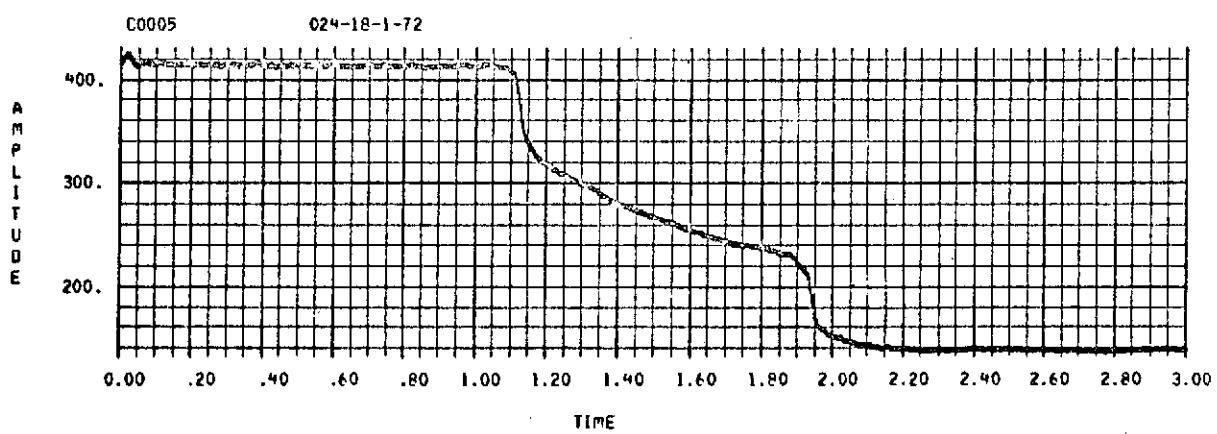
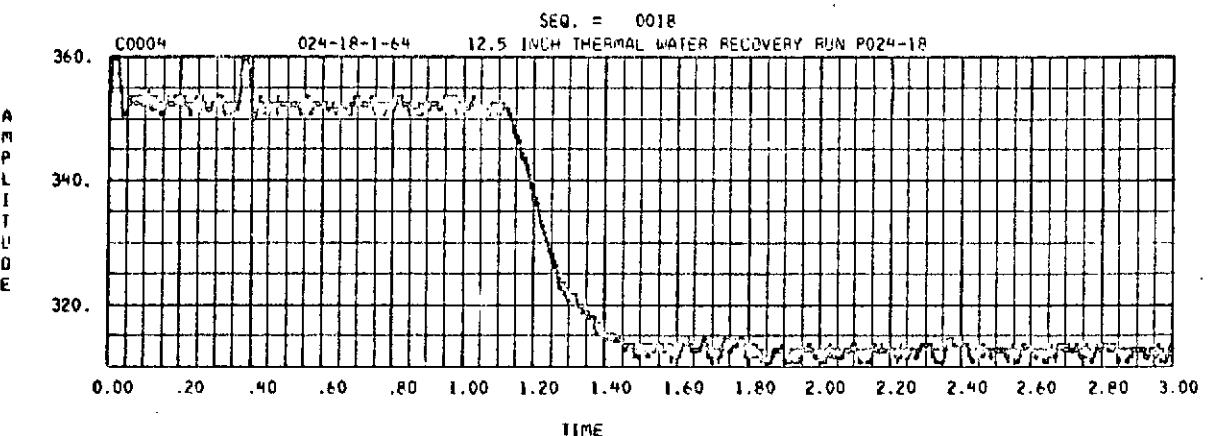


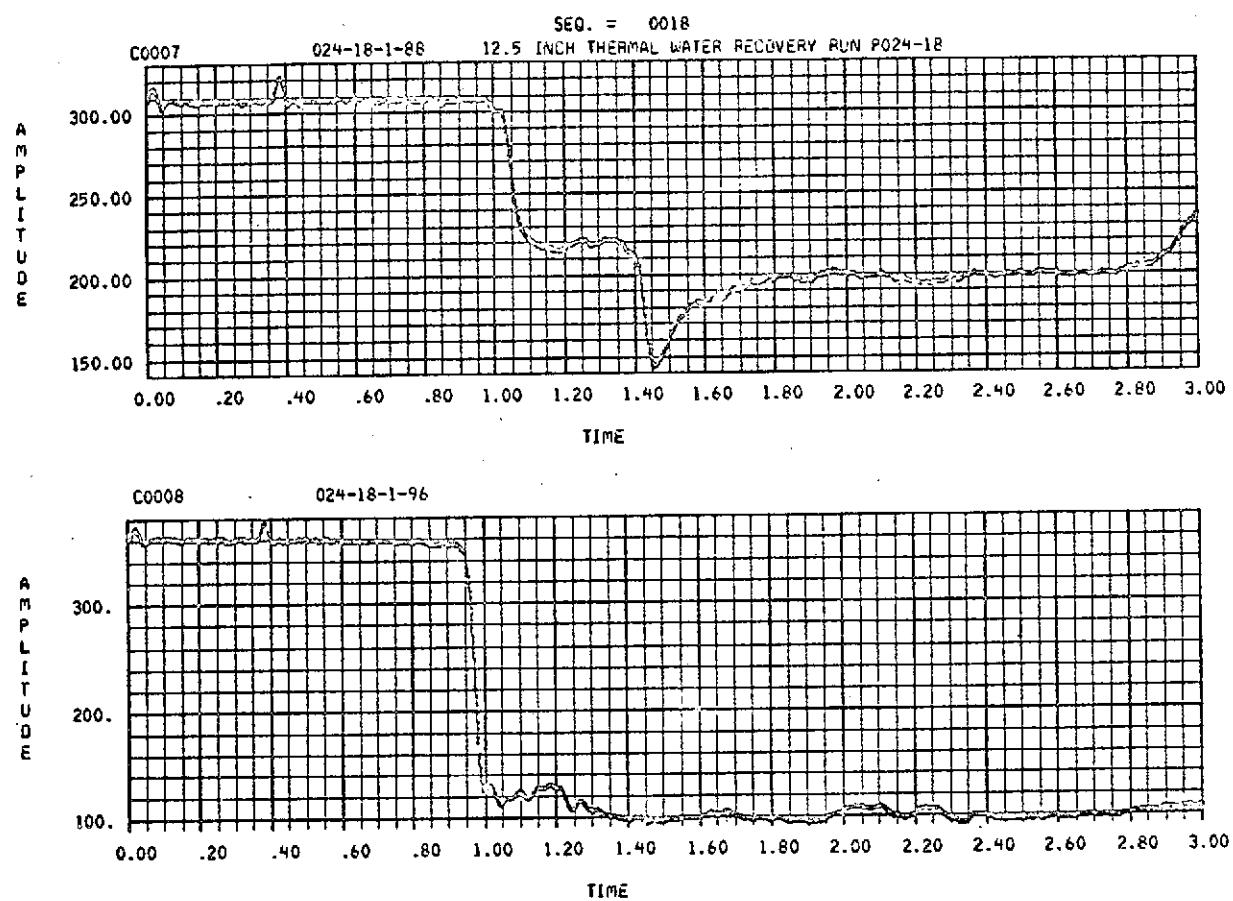
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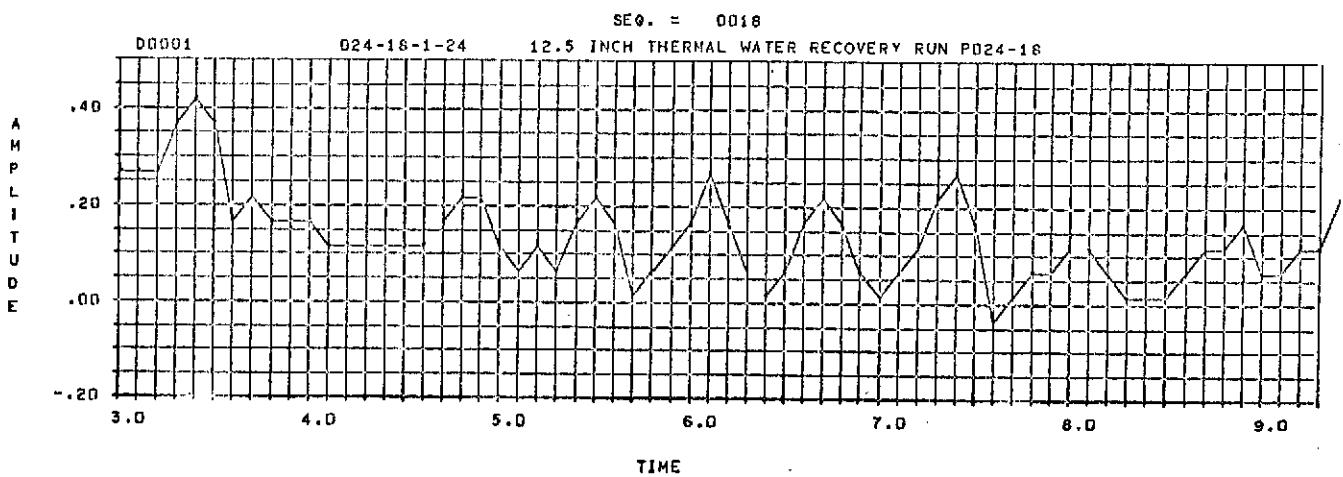
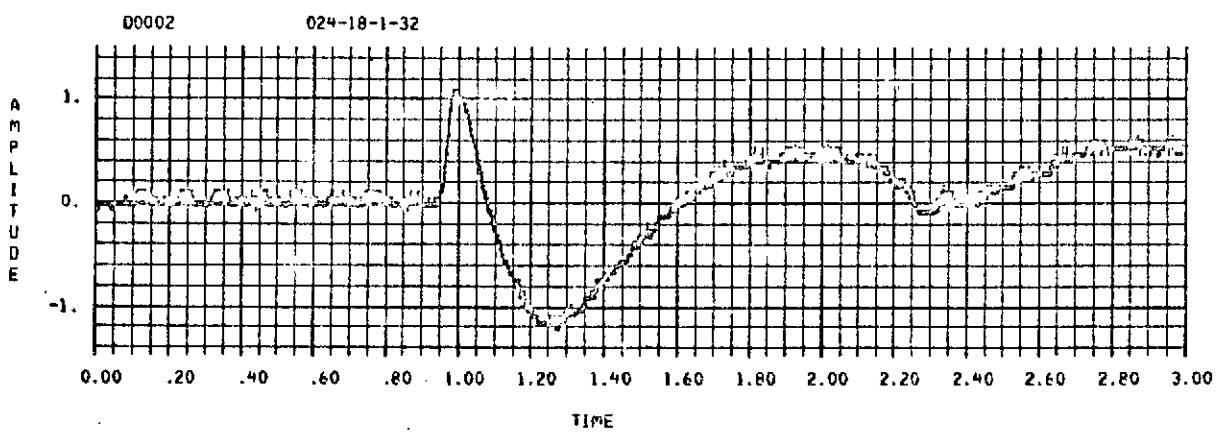
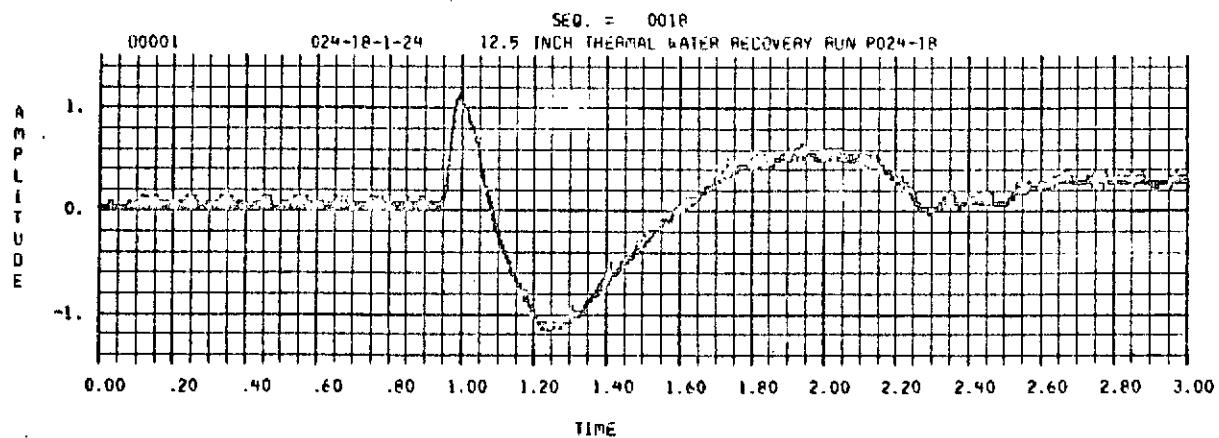
024-18-1-120 12.5 INCH THERMAL WATER RECOVERY RUN F024-18





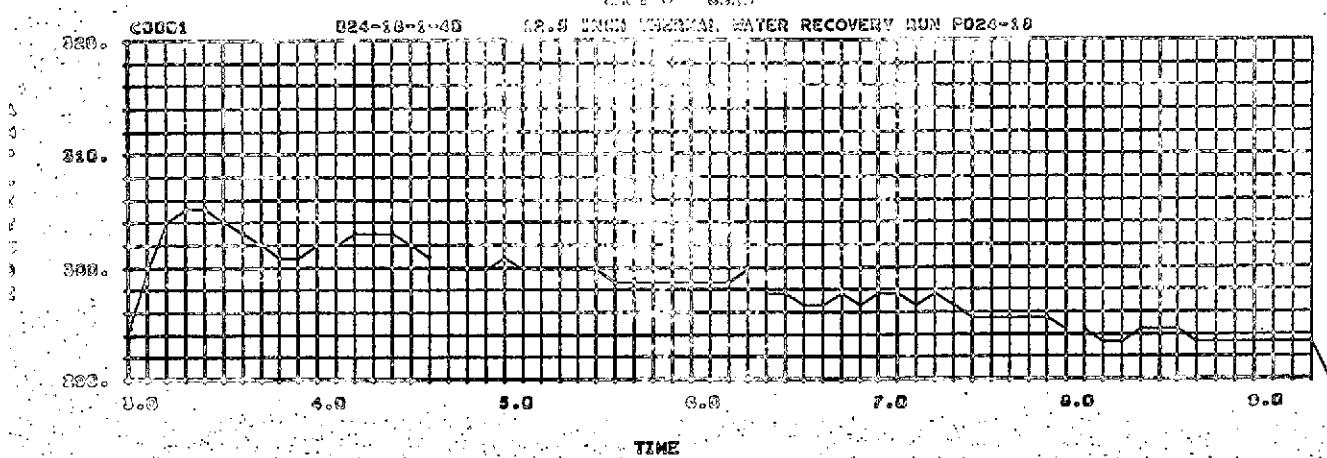






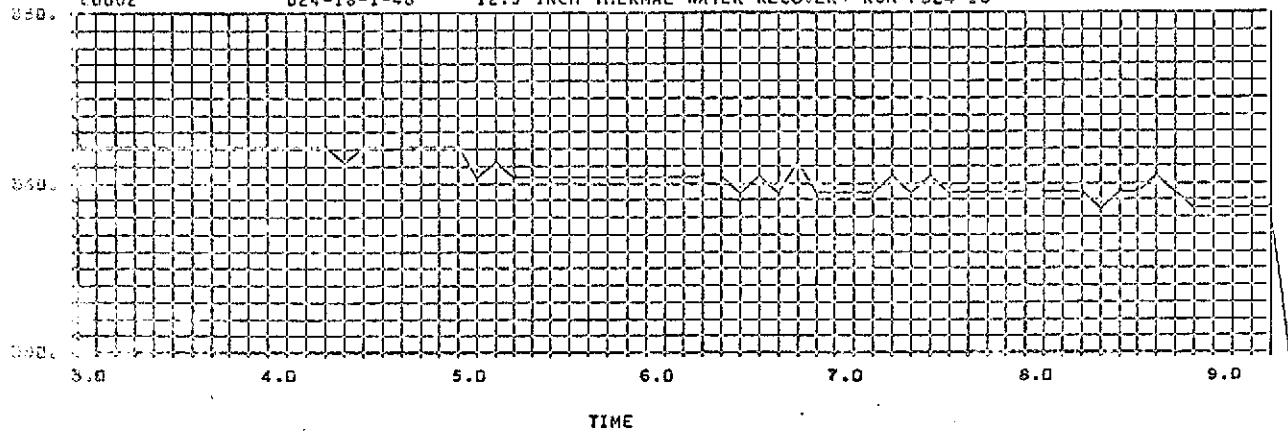
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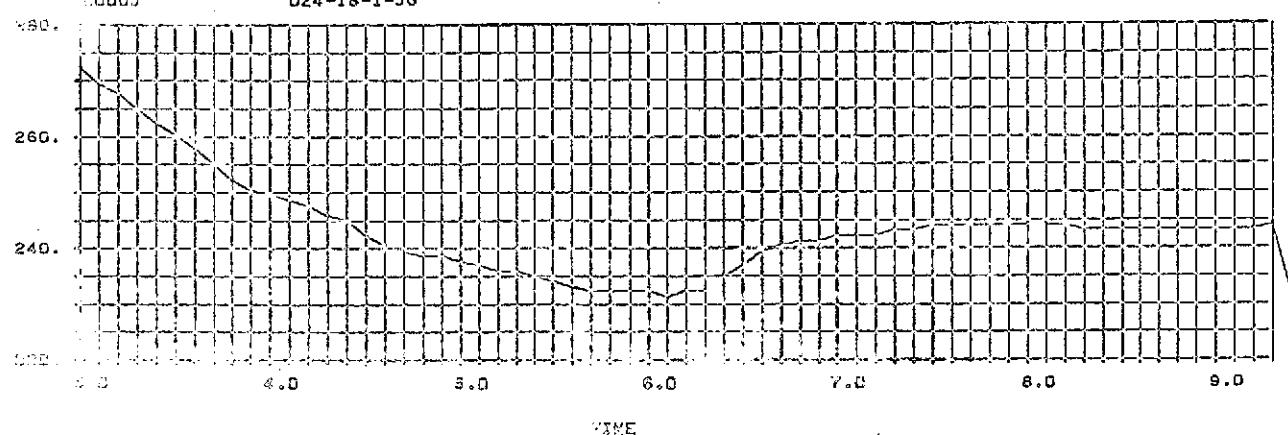


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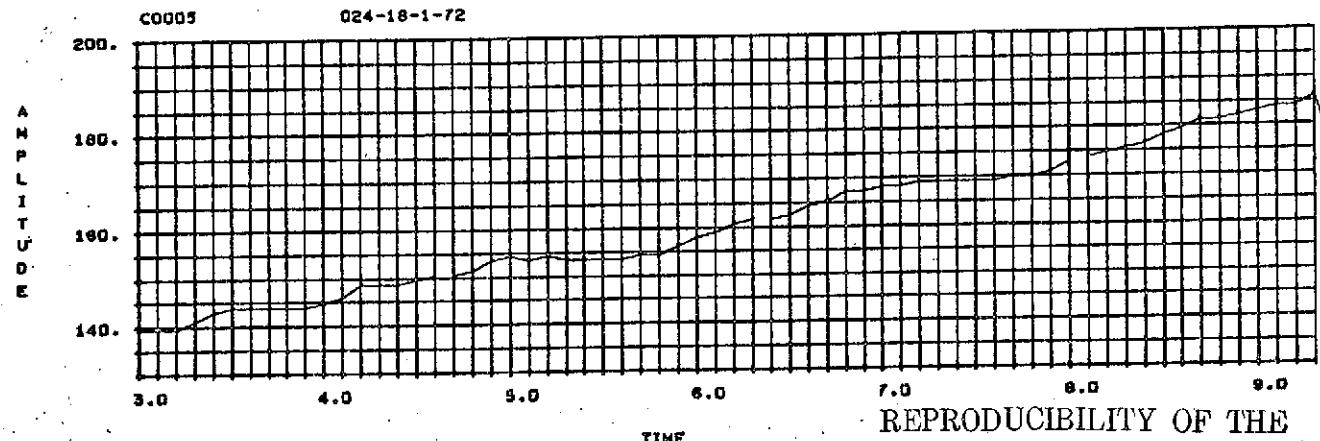
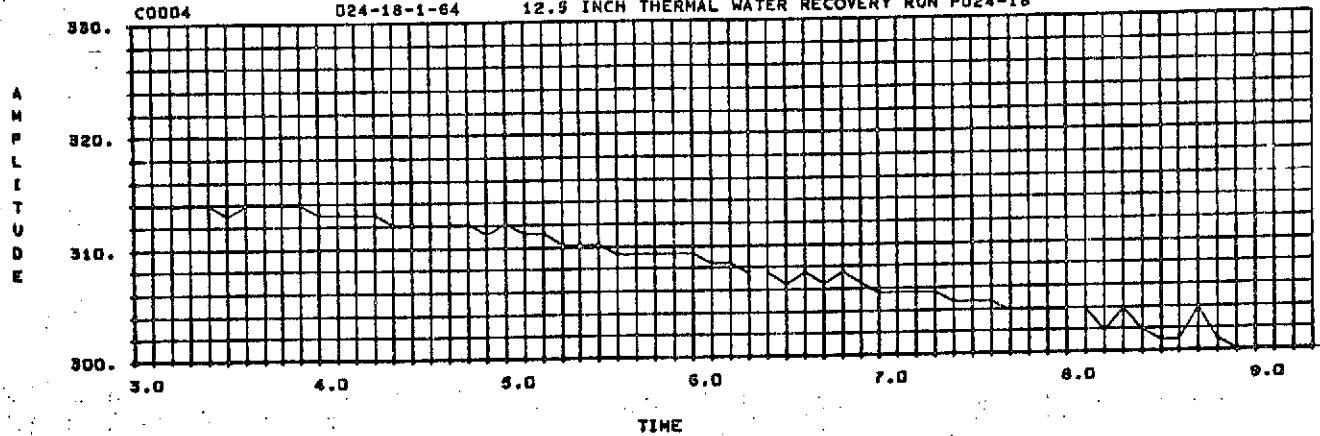
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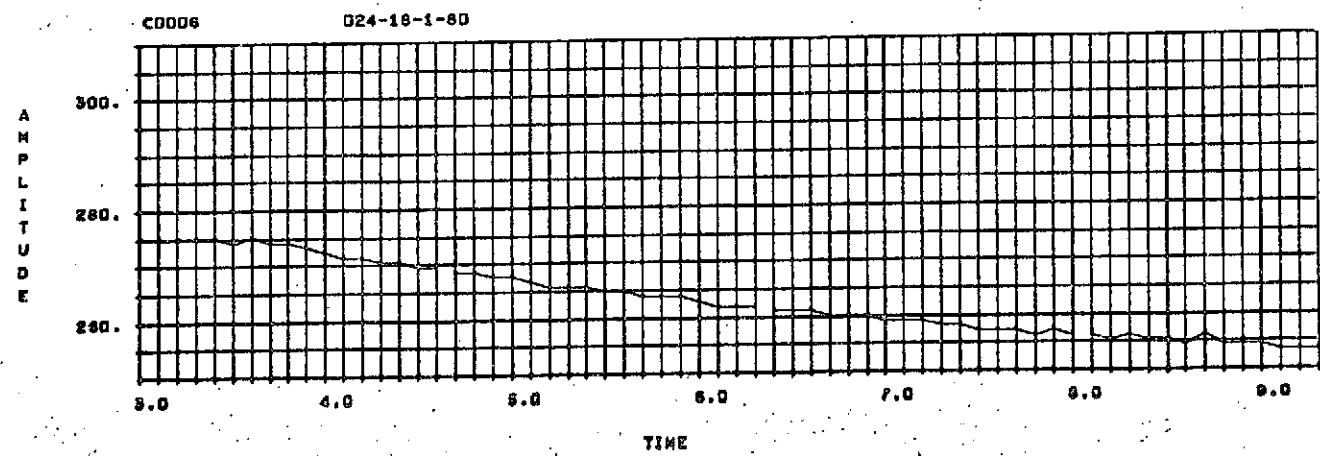
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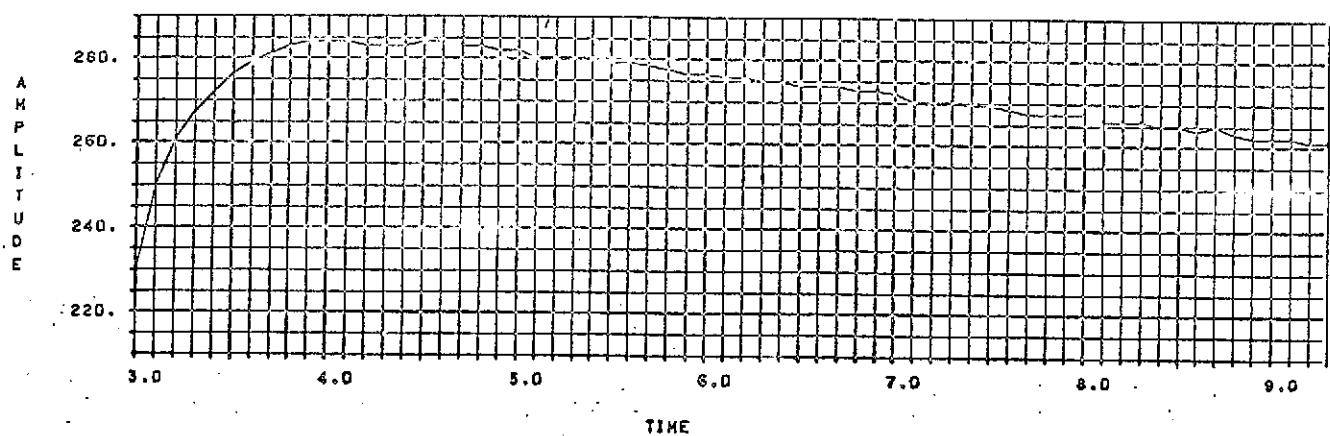


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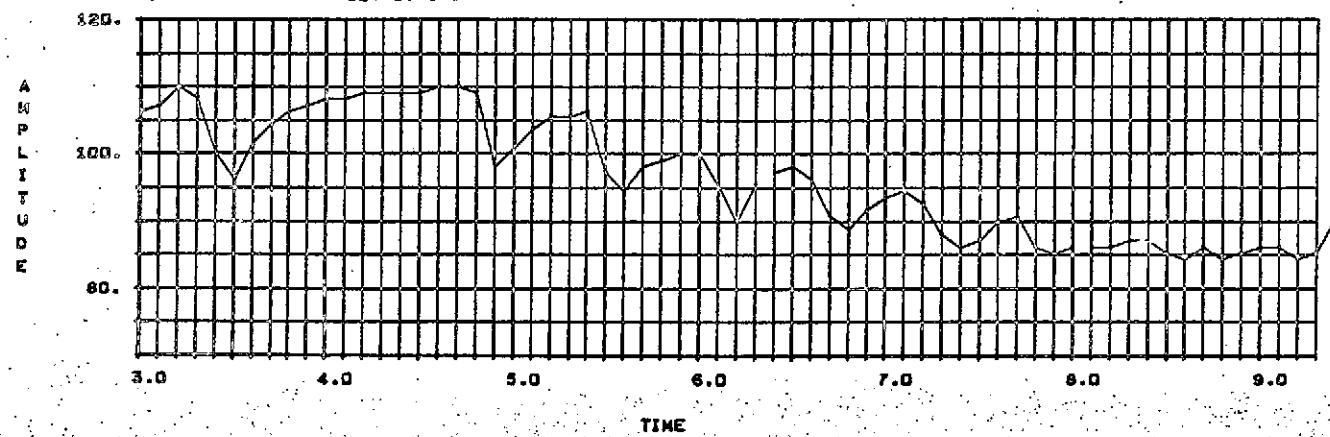
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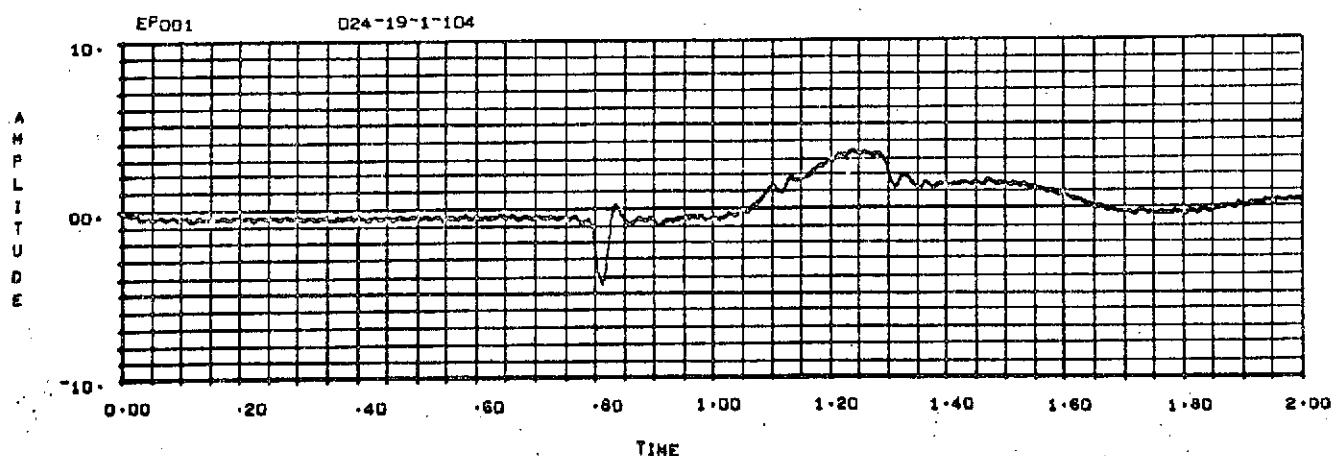
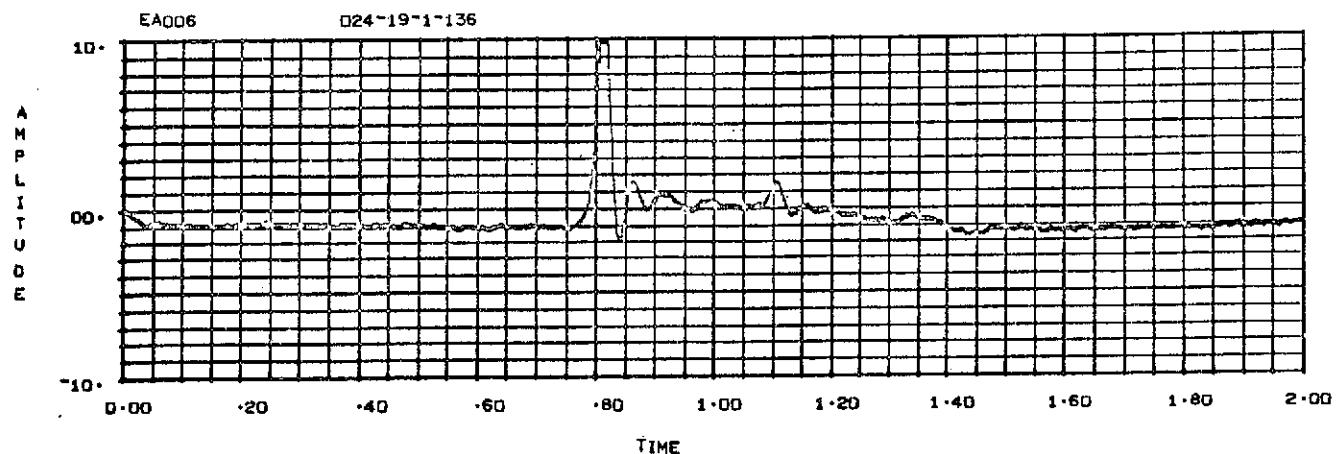
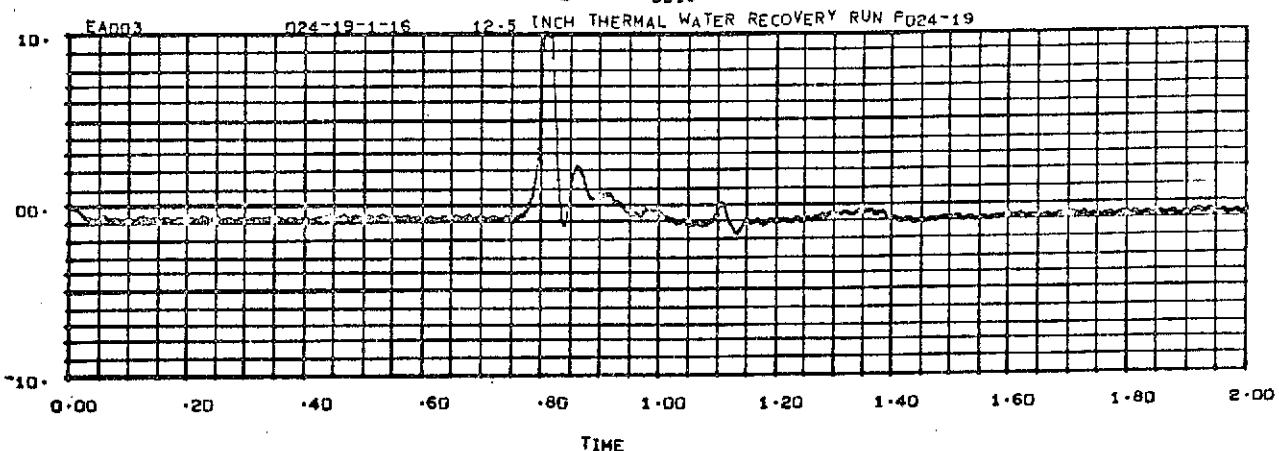


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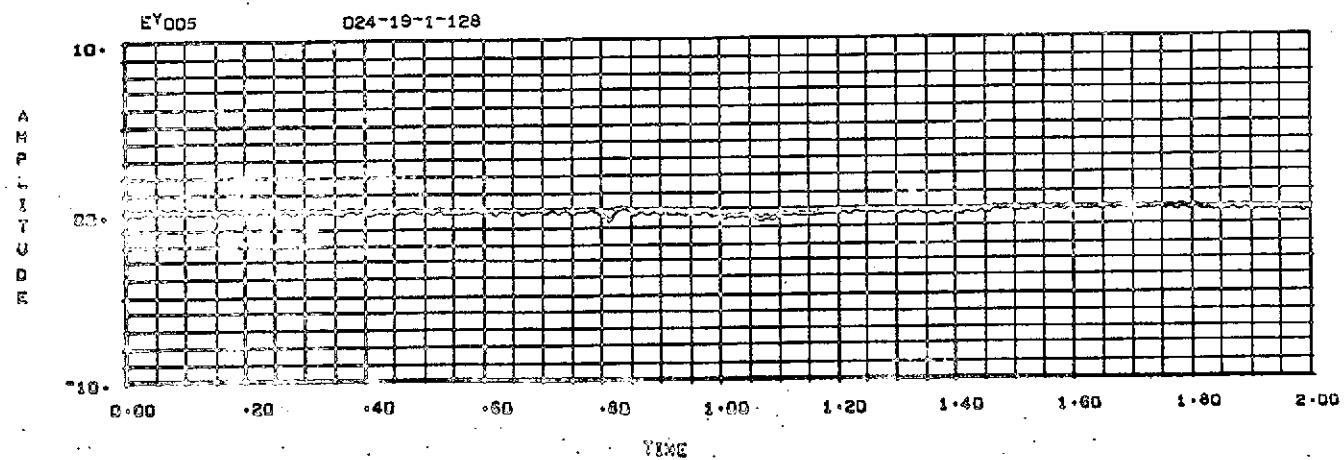
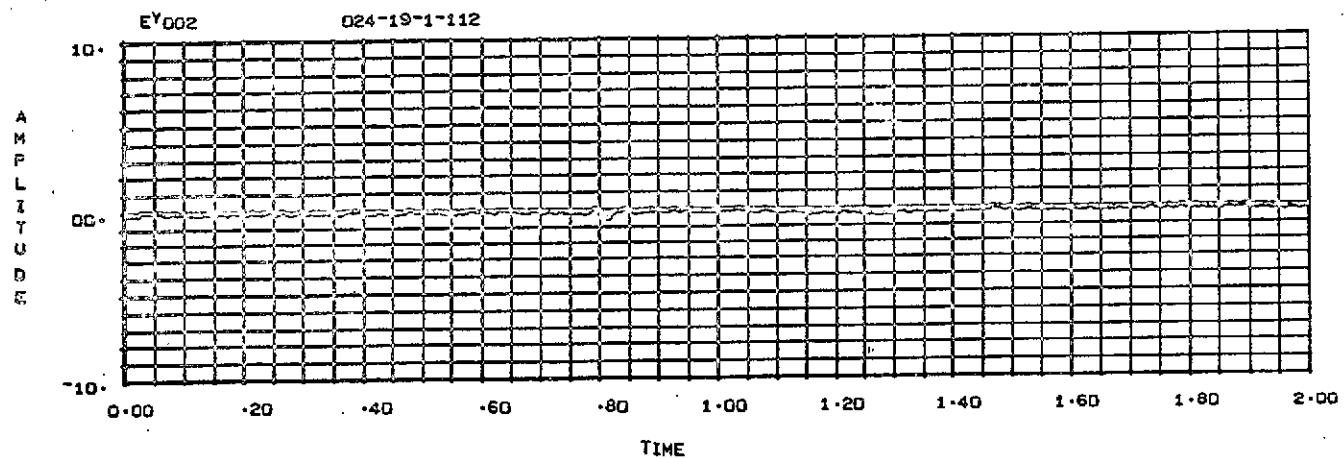
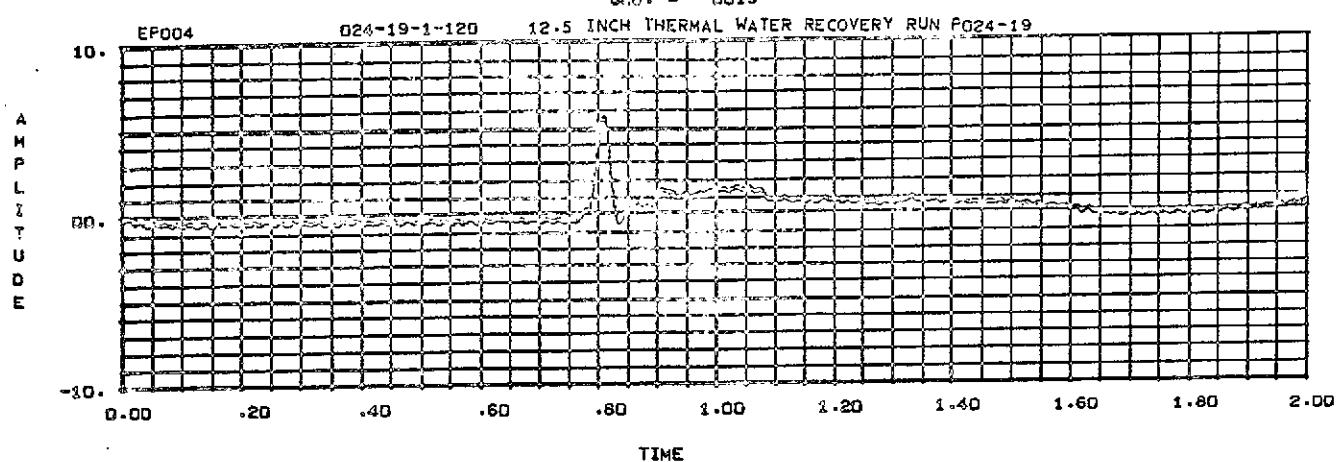


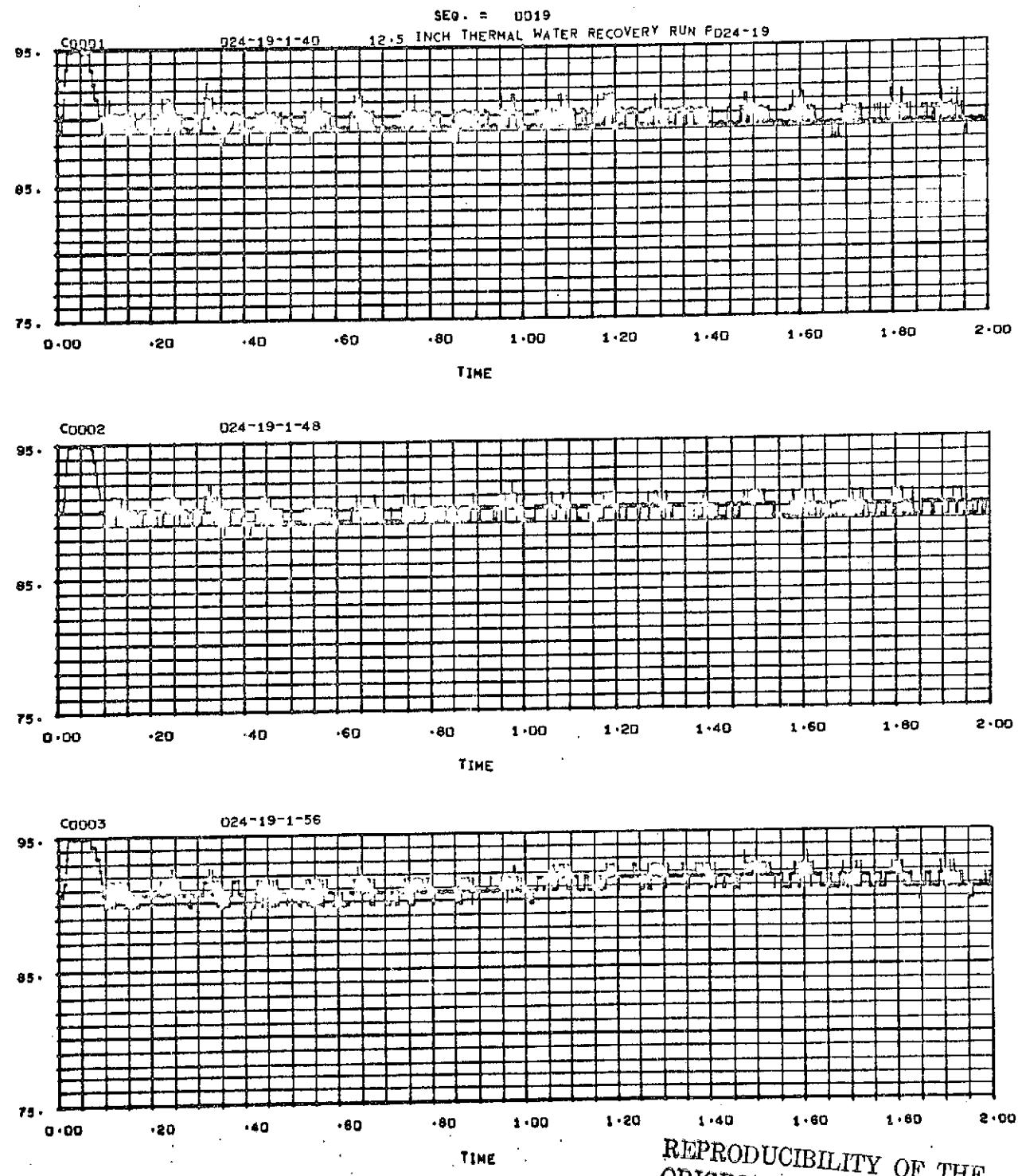
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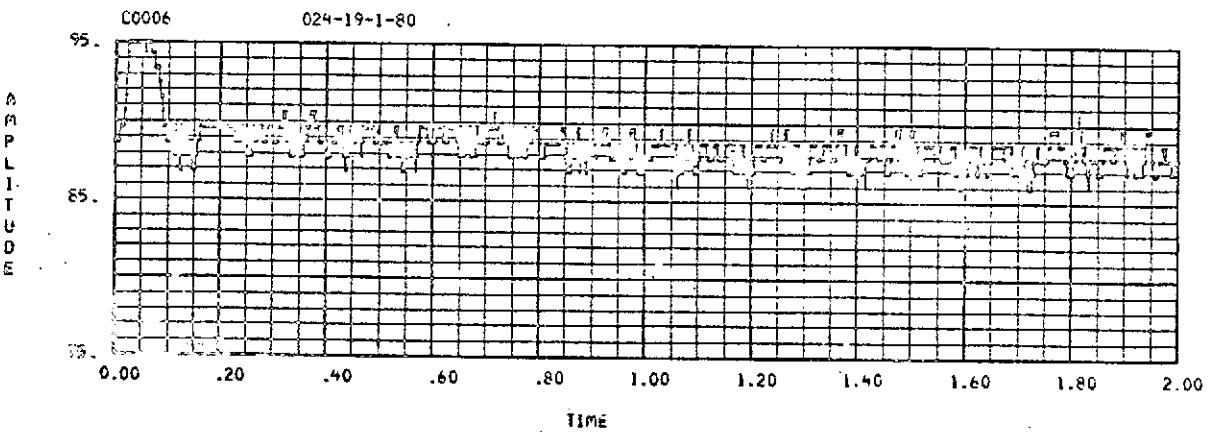
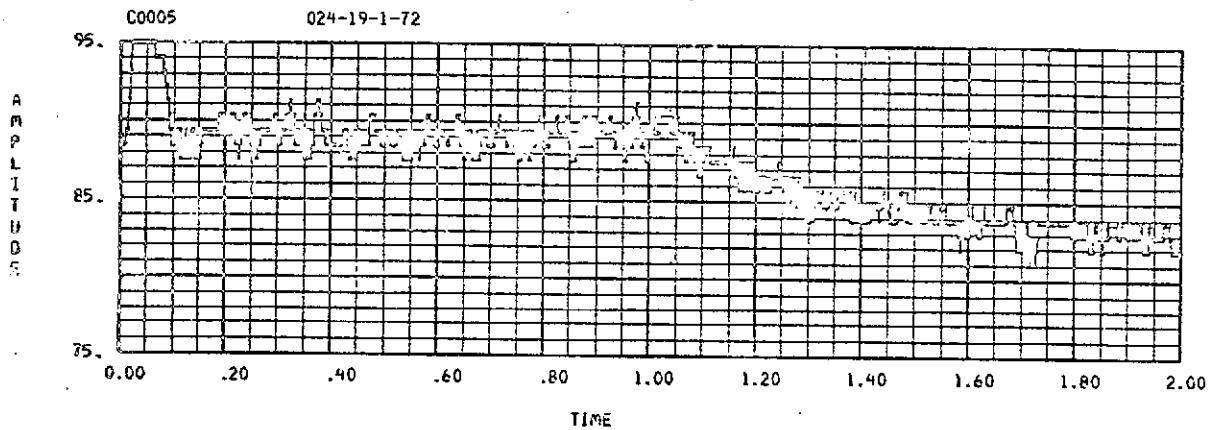
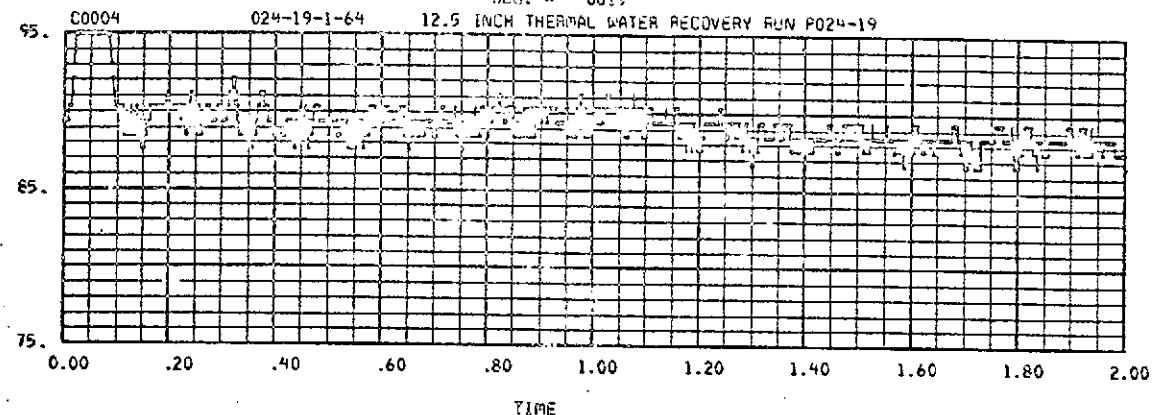
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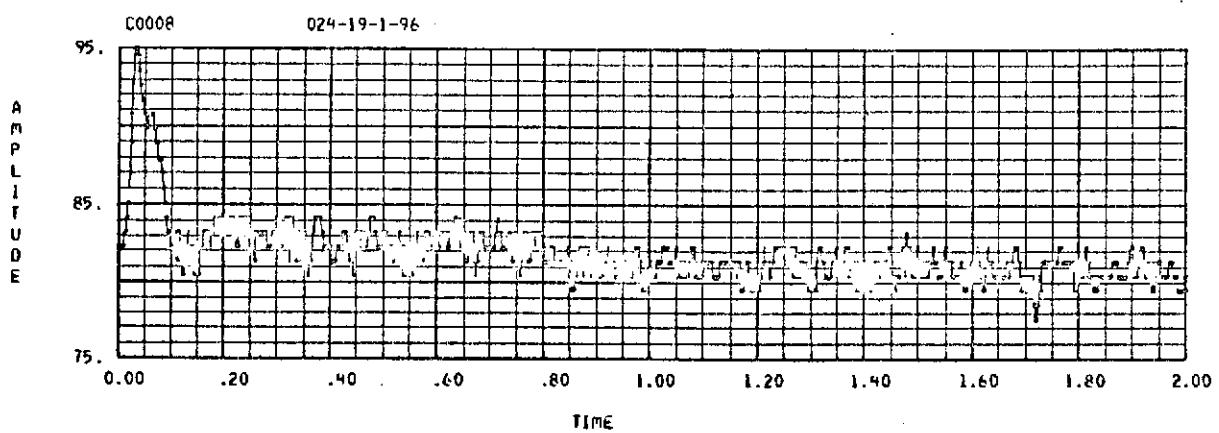
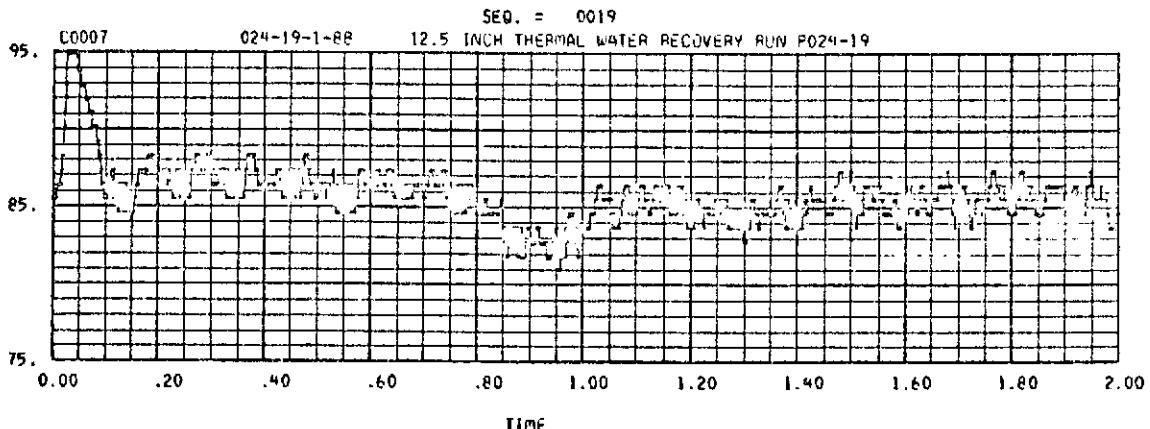




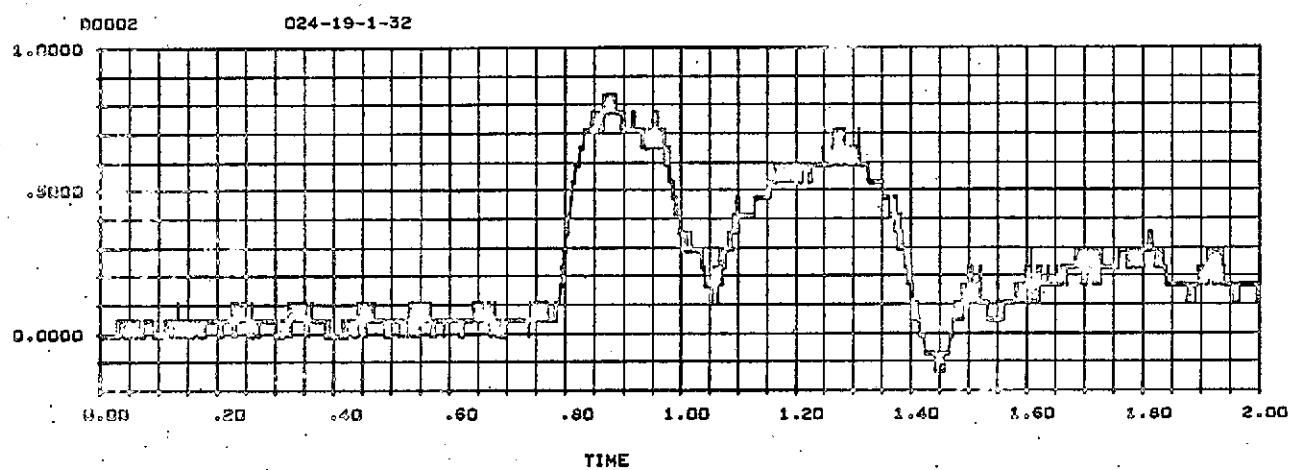
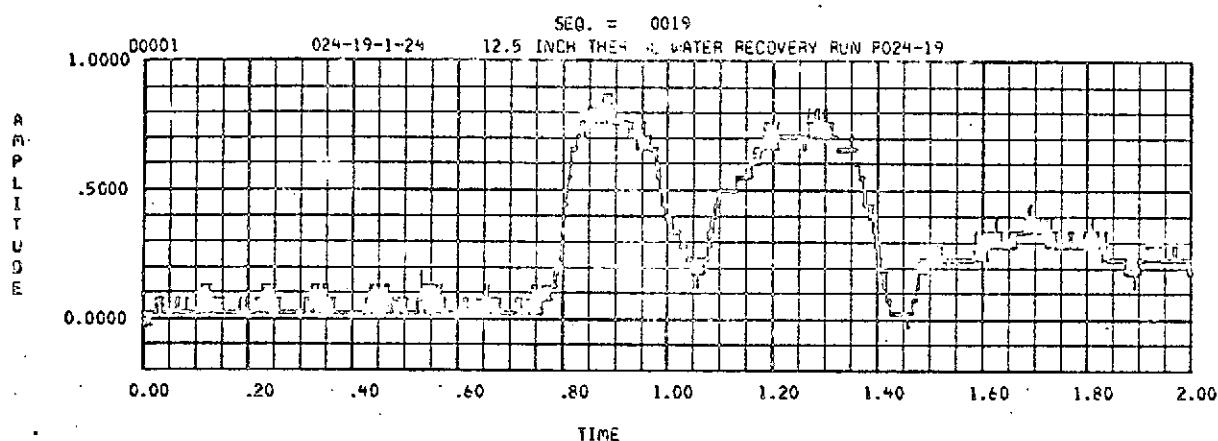
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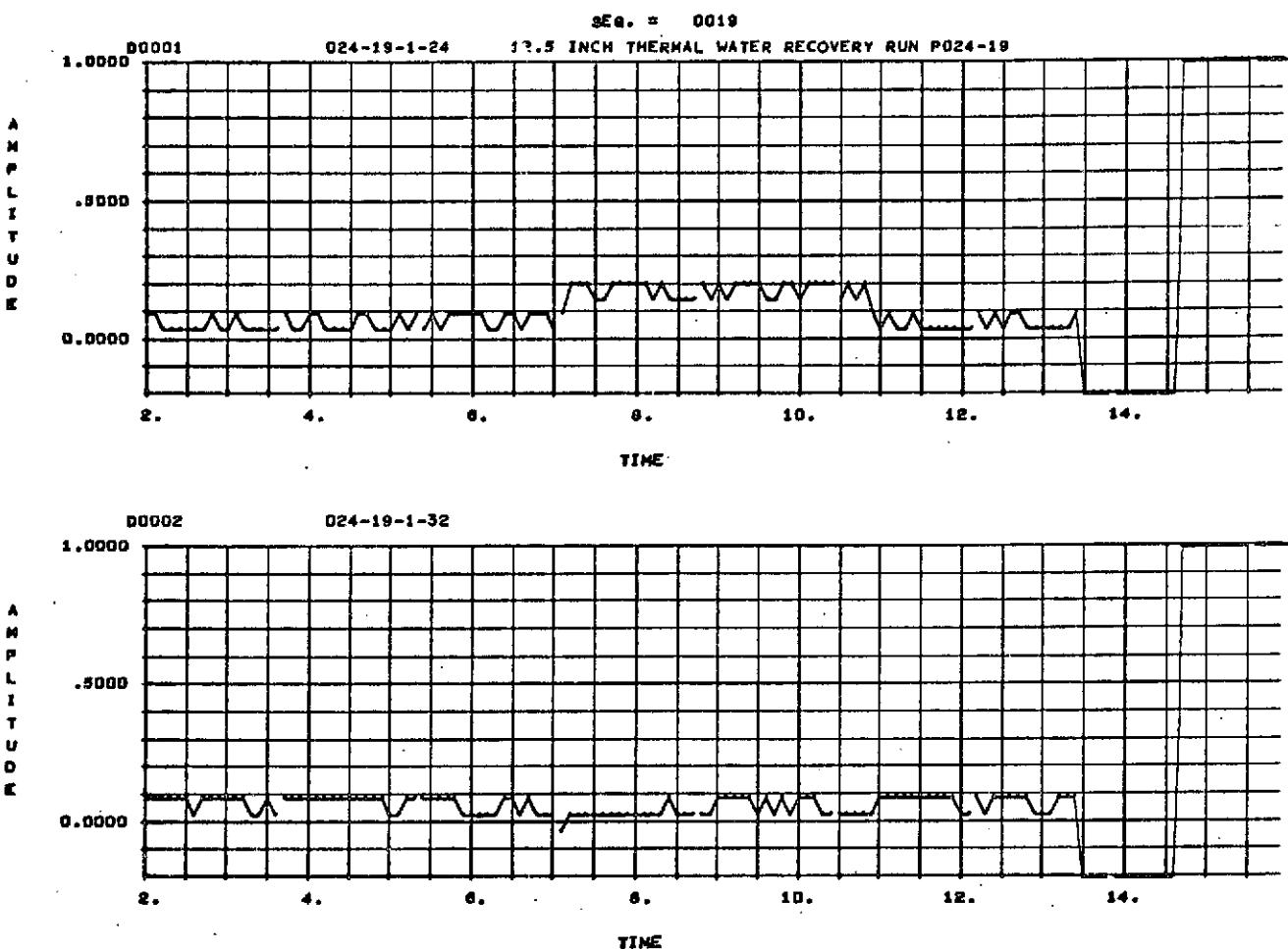
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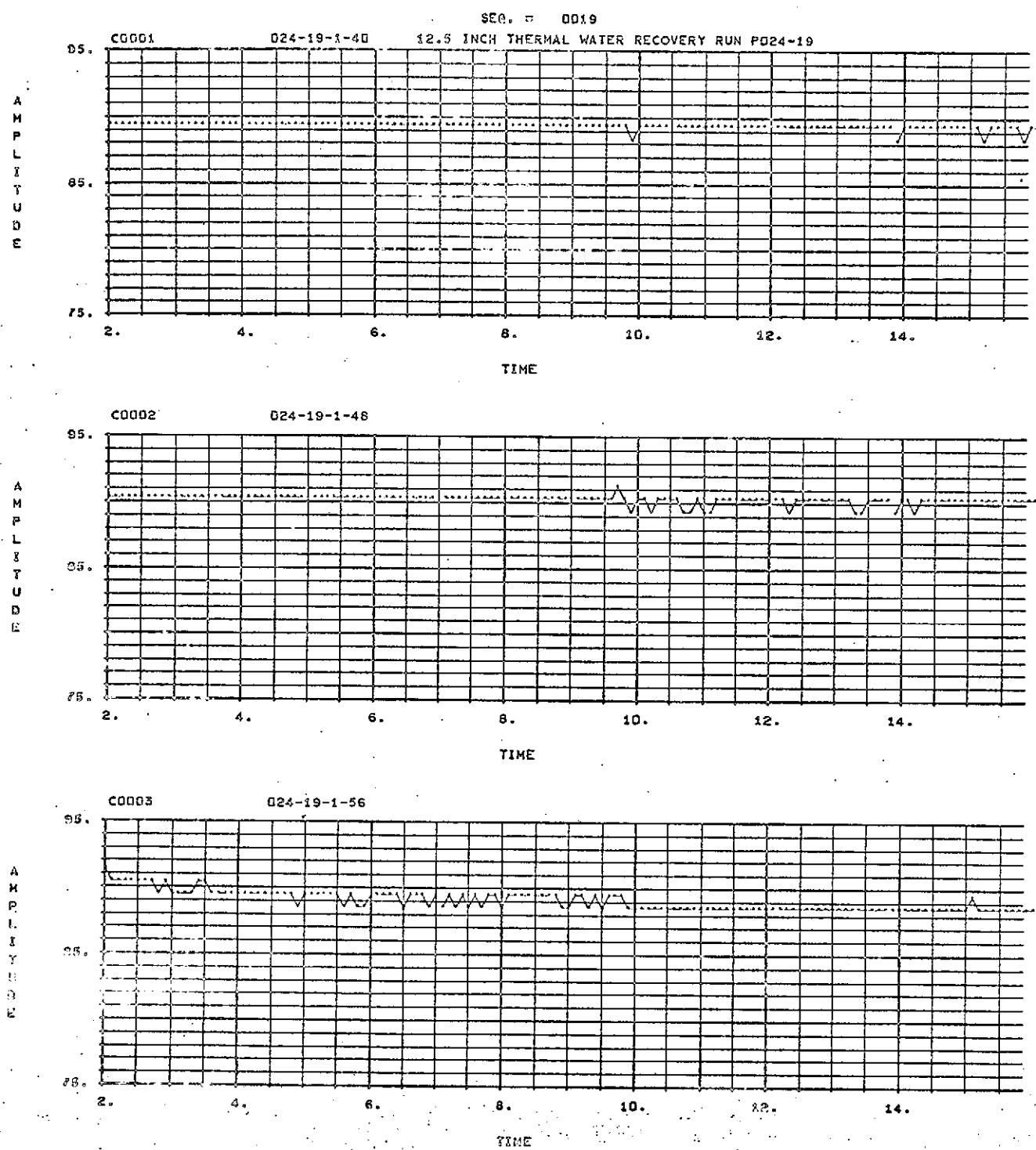


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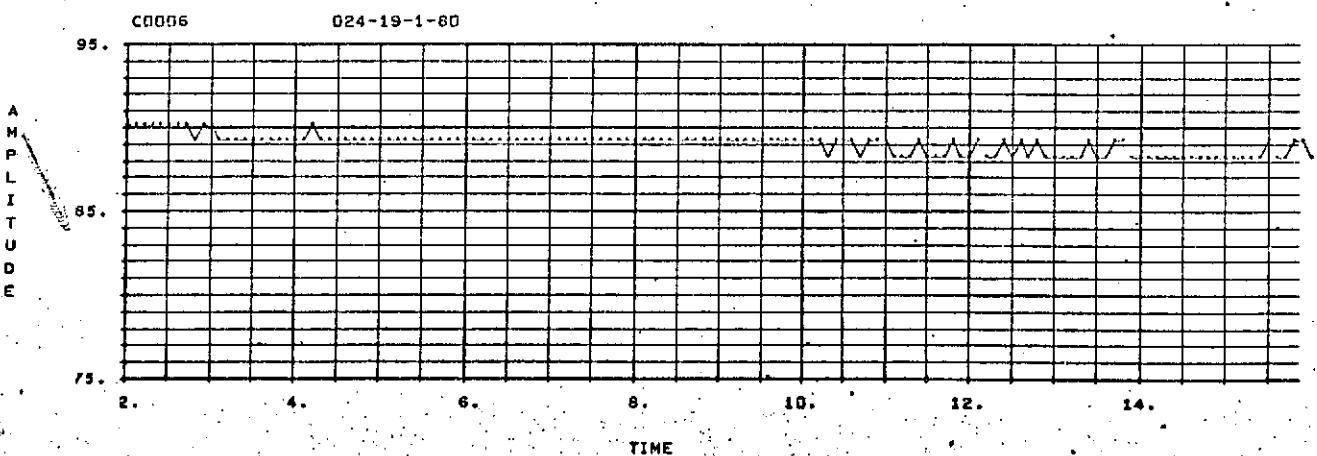
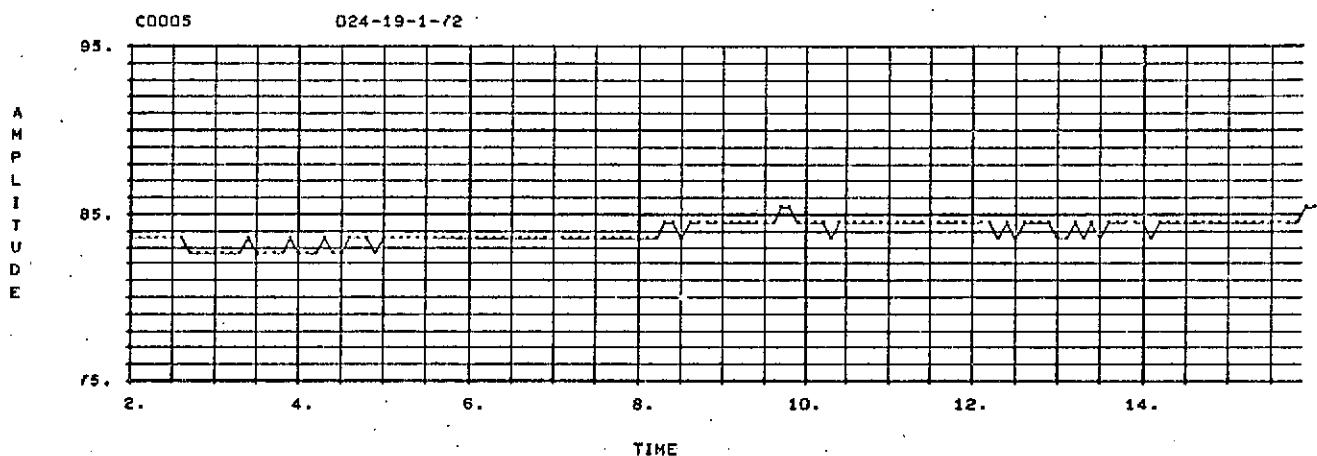
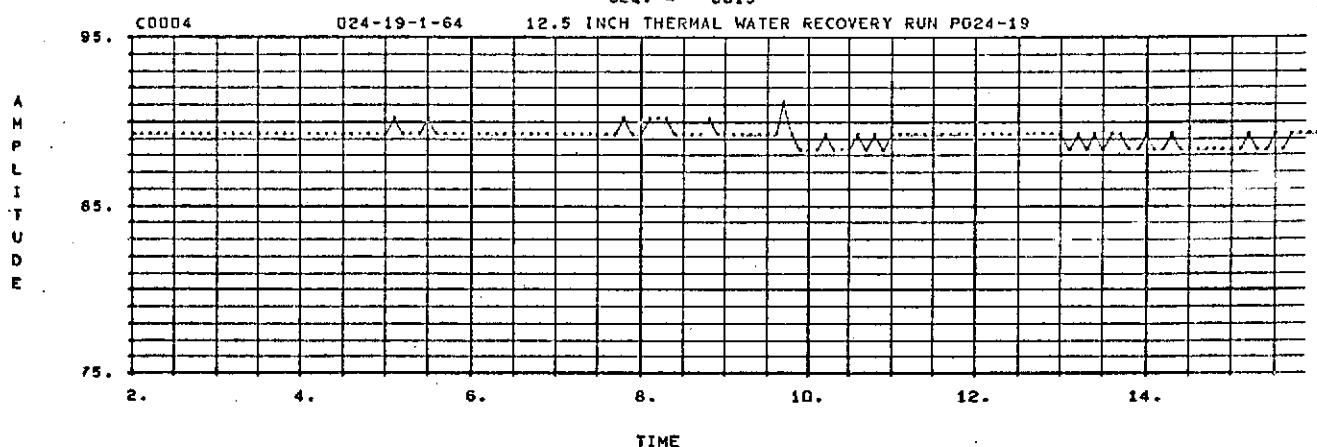




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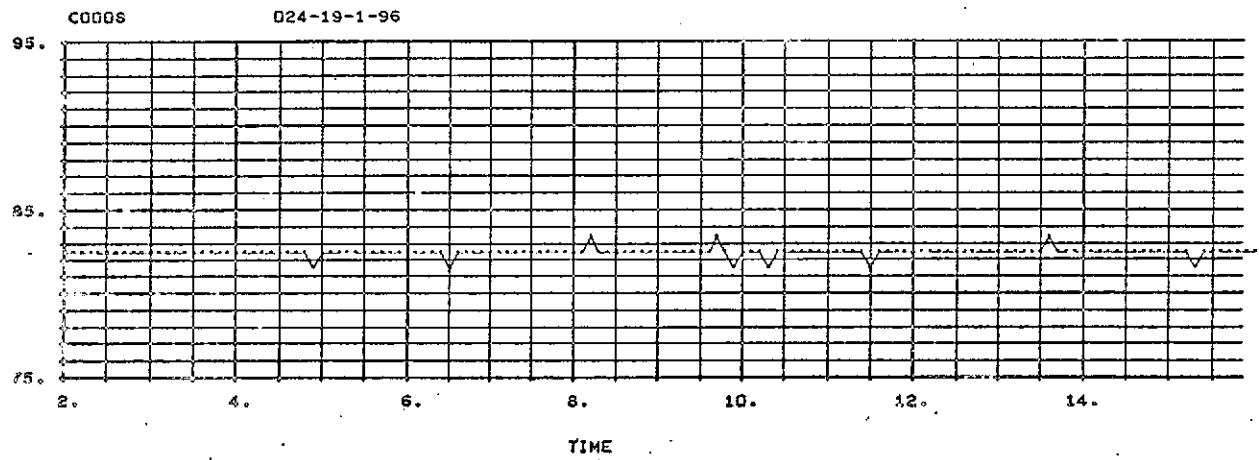
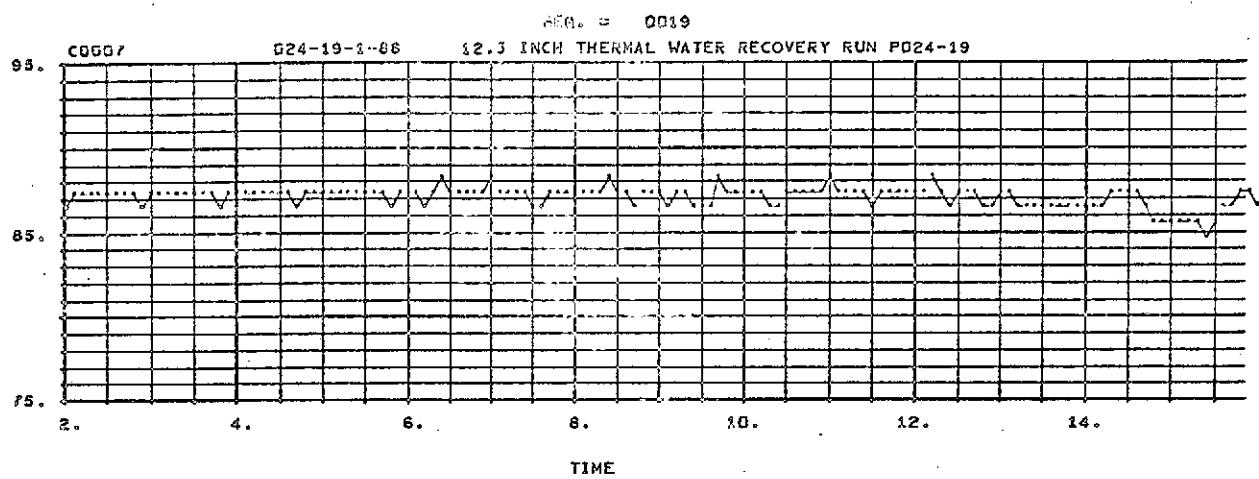


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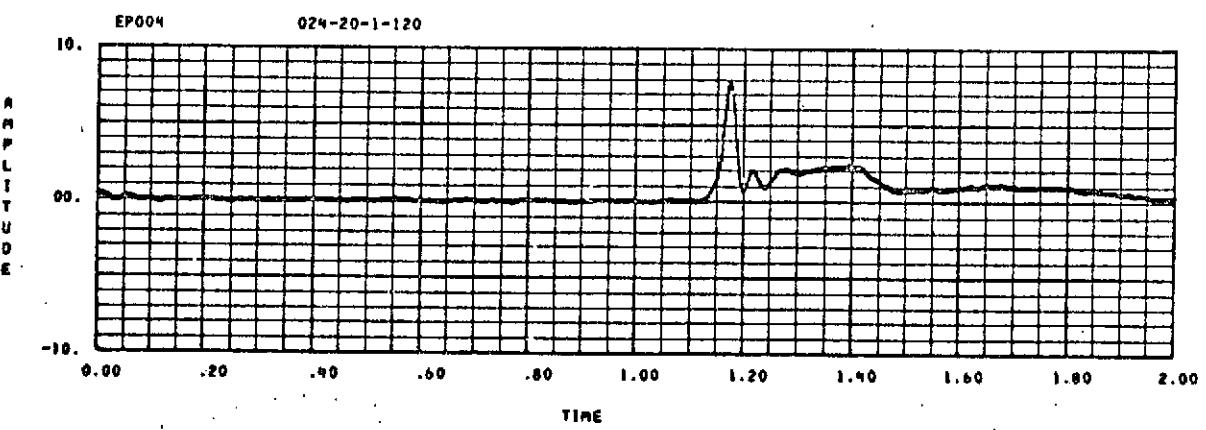
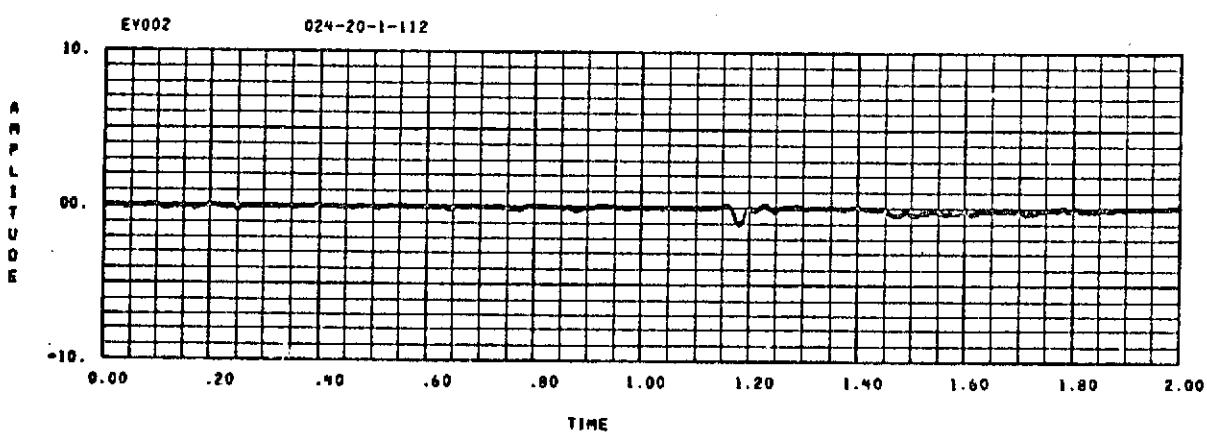
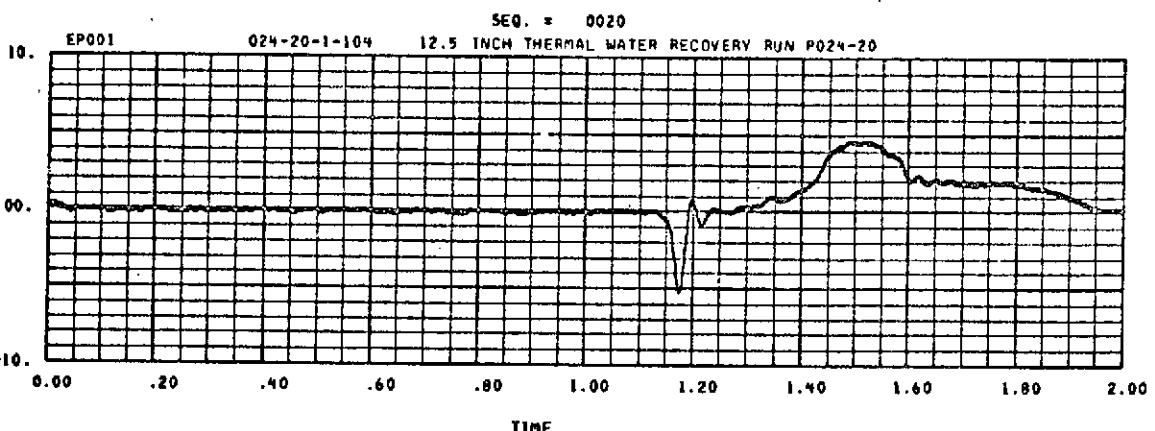


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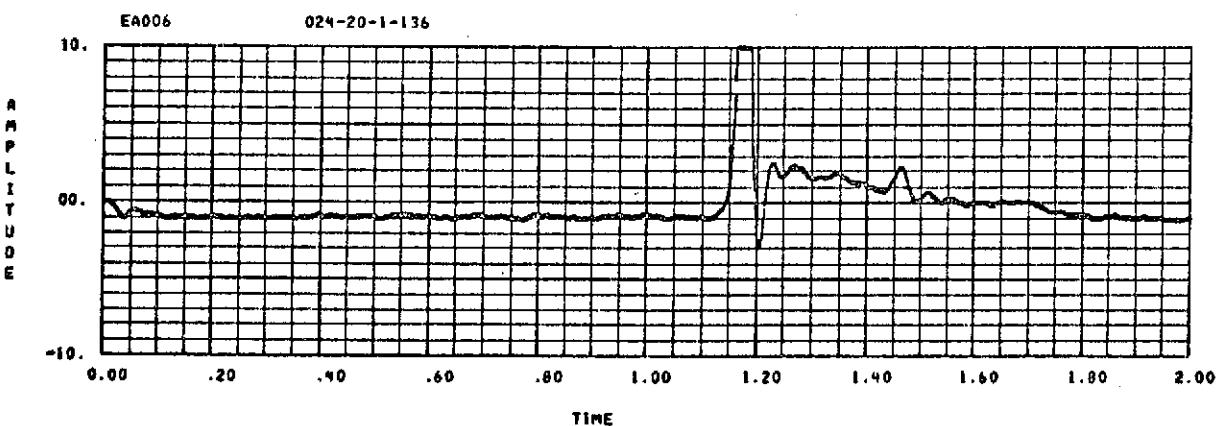
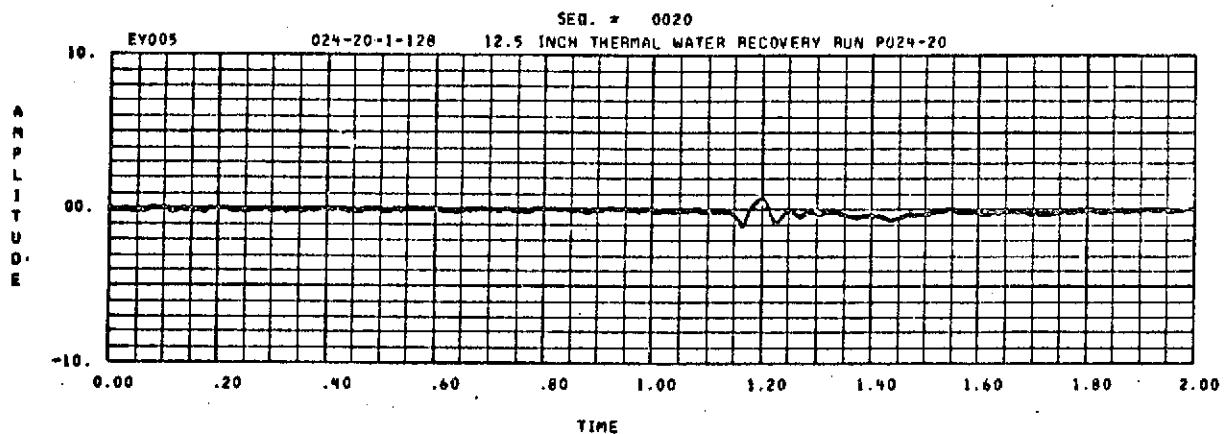
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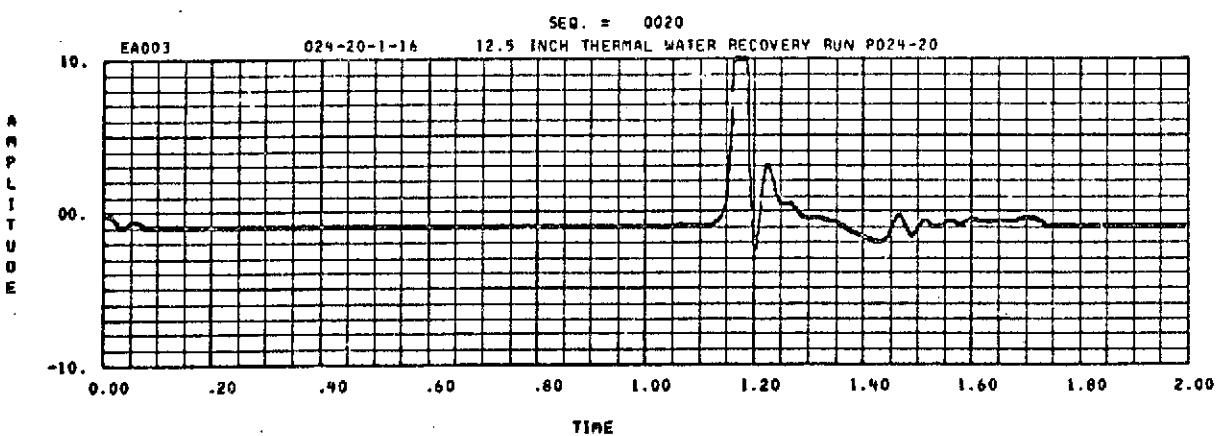
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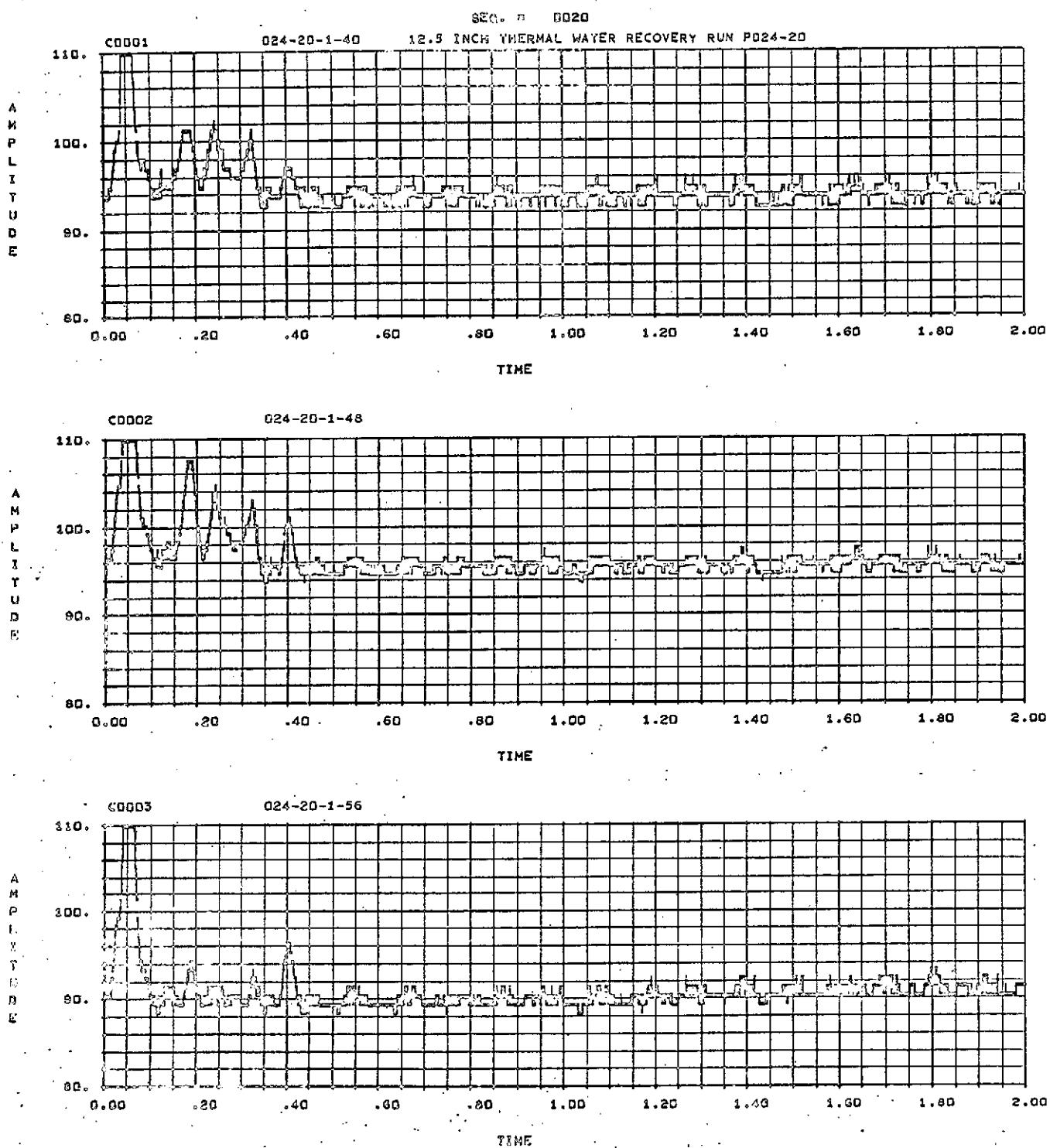


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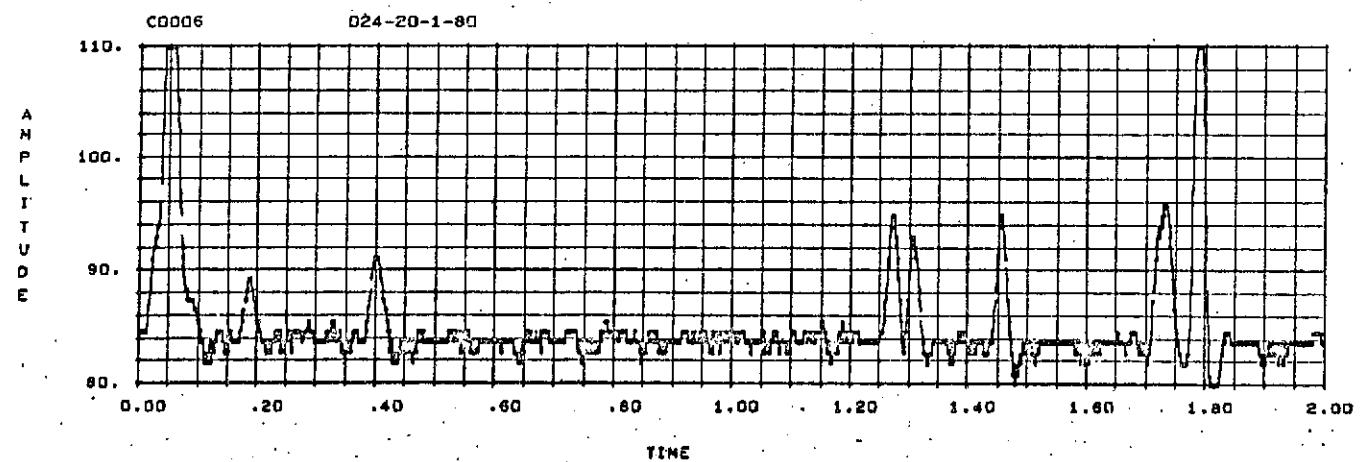
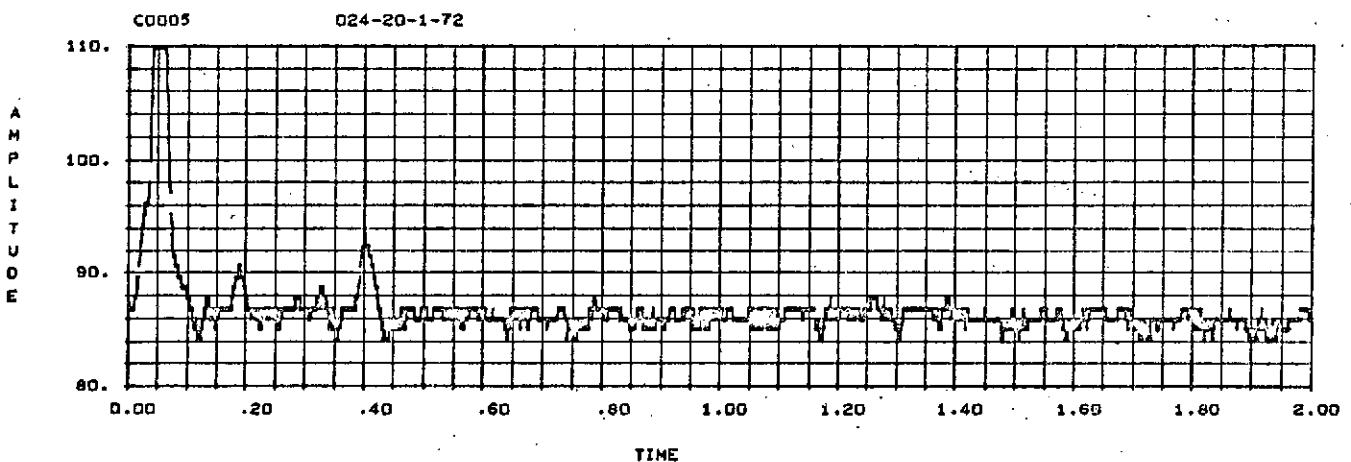
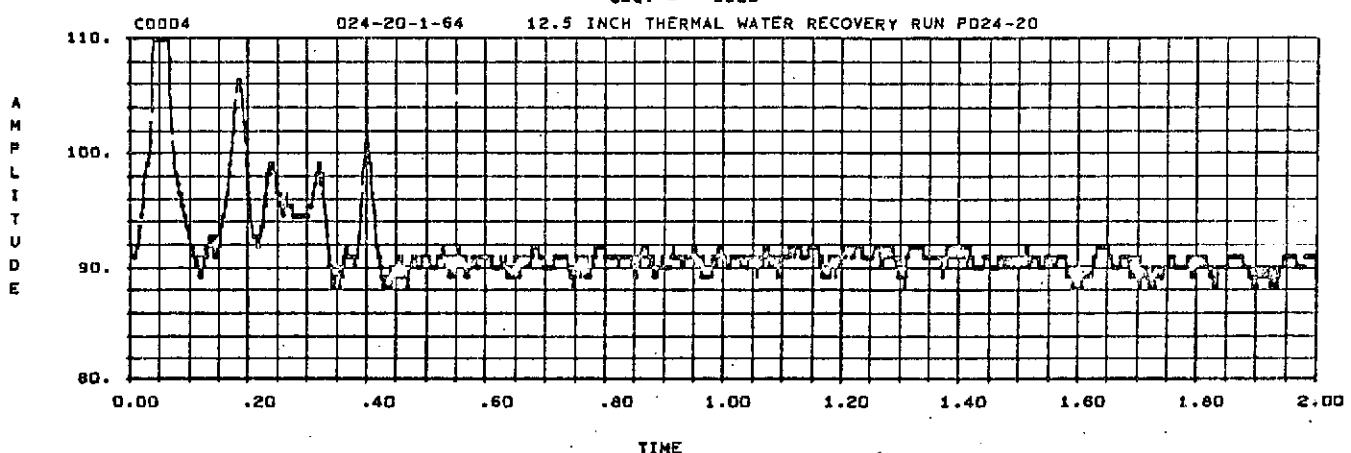


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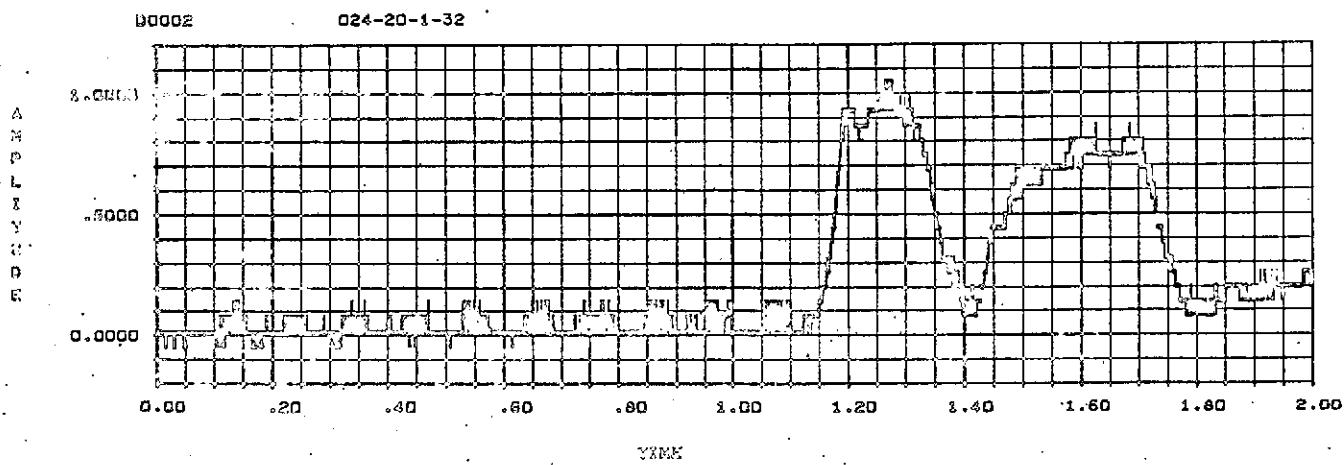
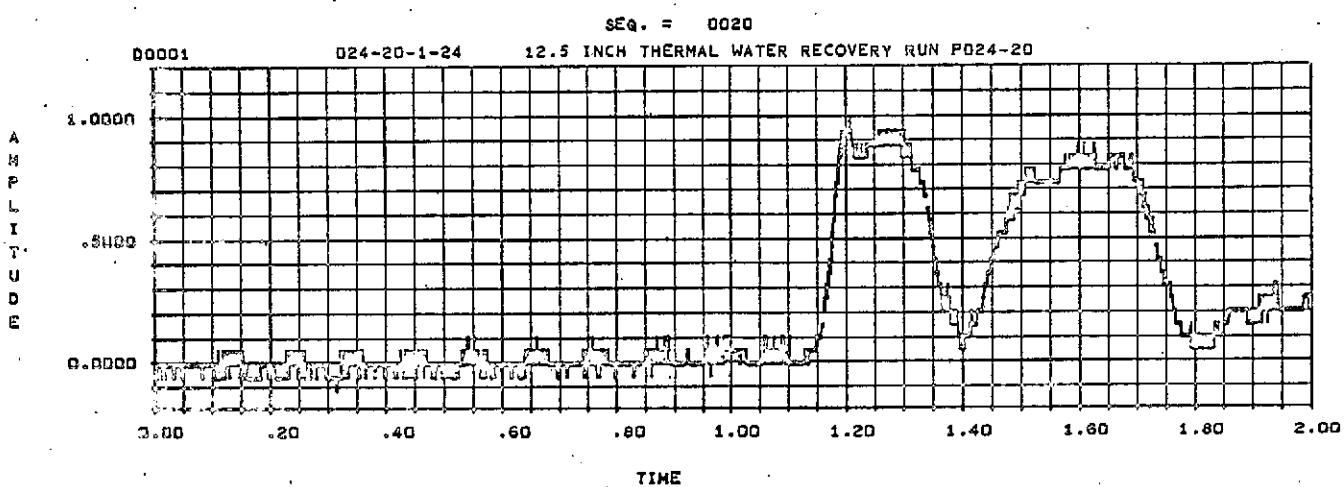
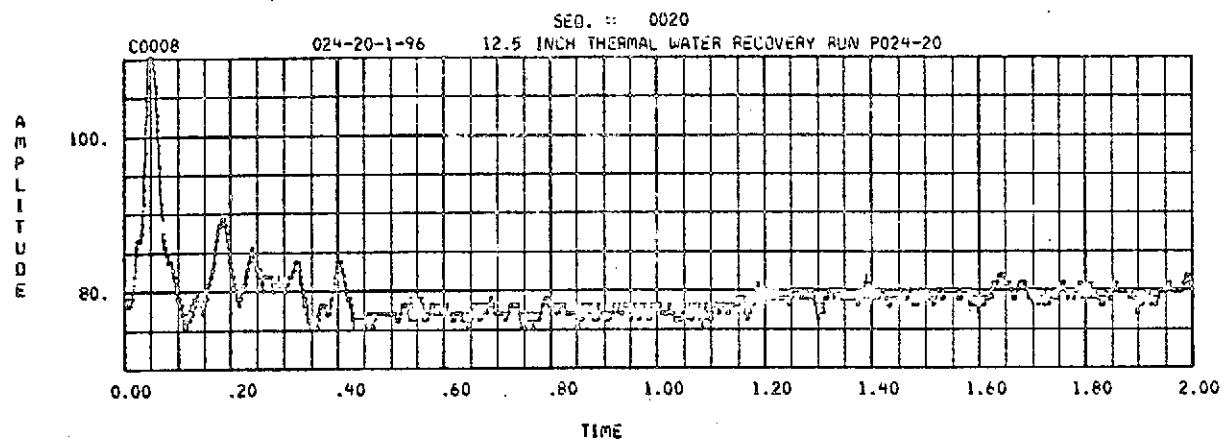


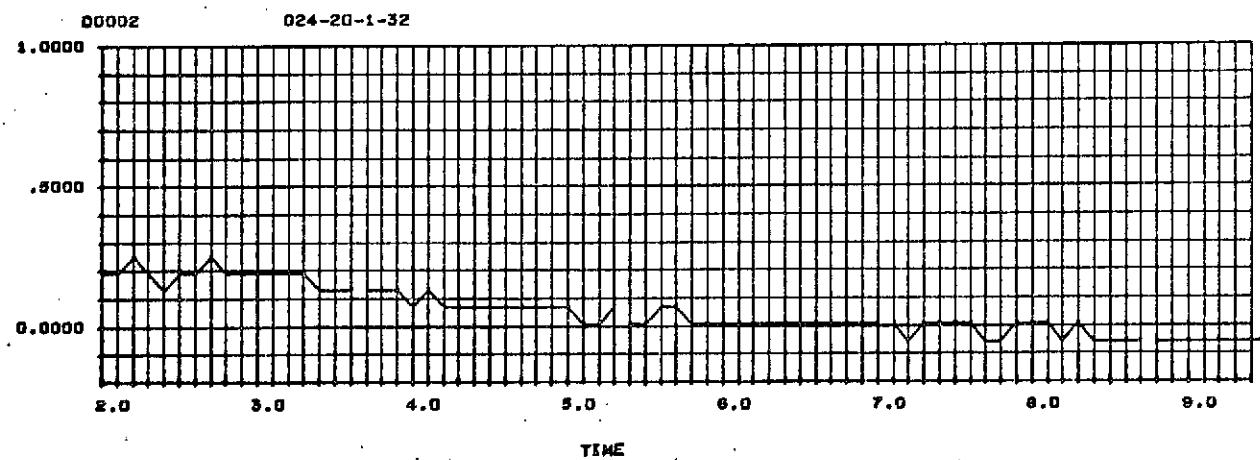
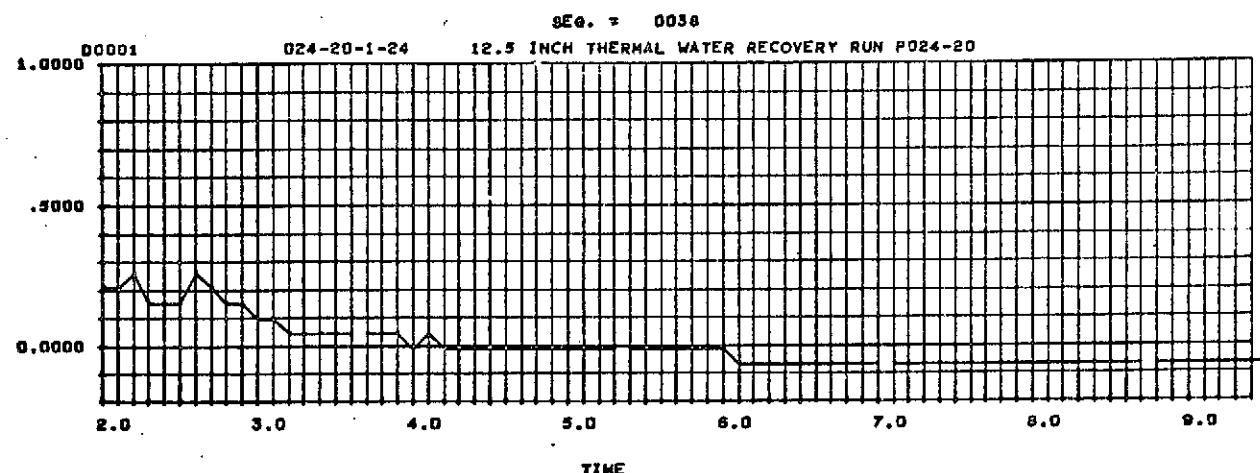
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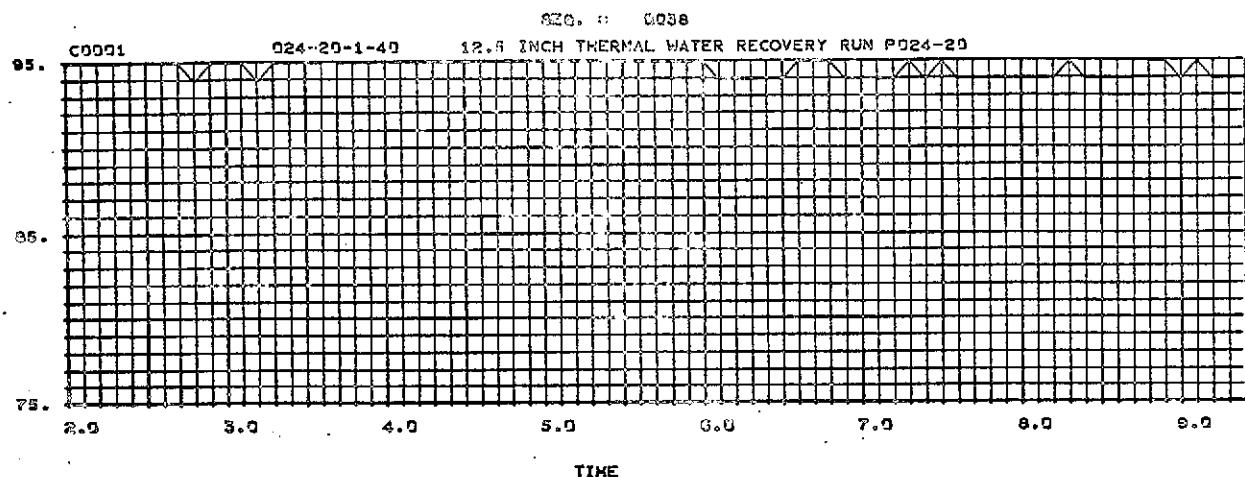
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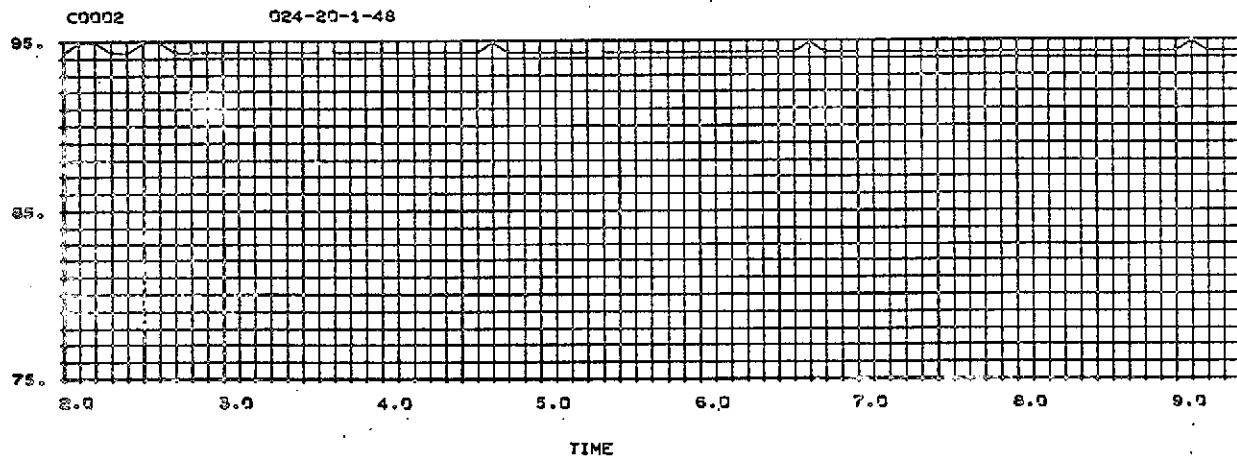


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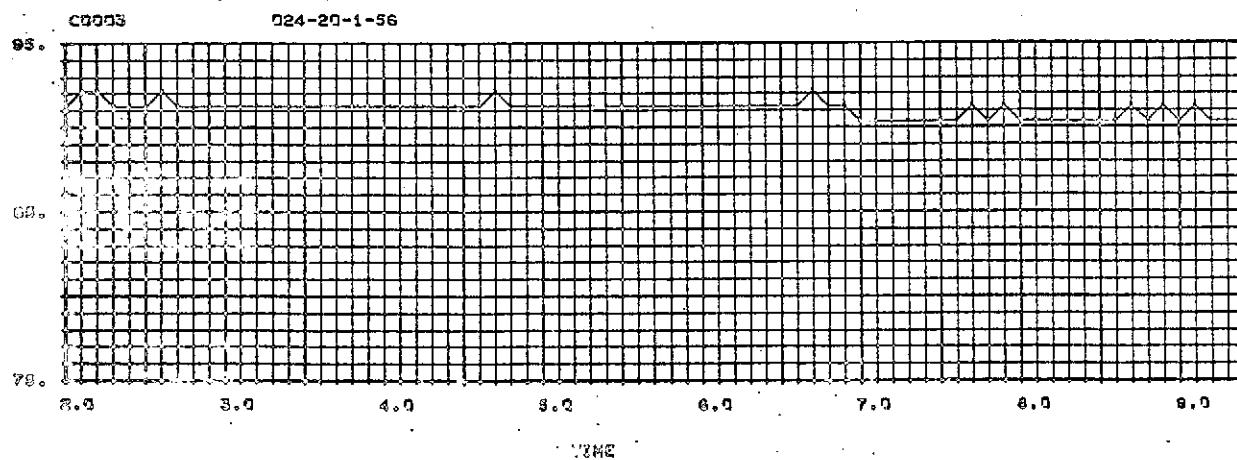
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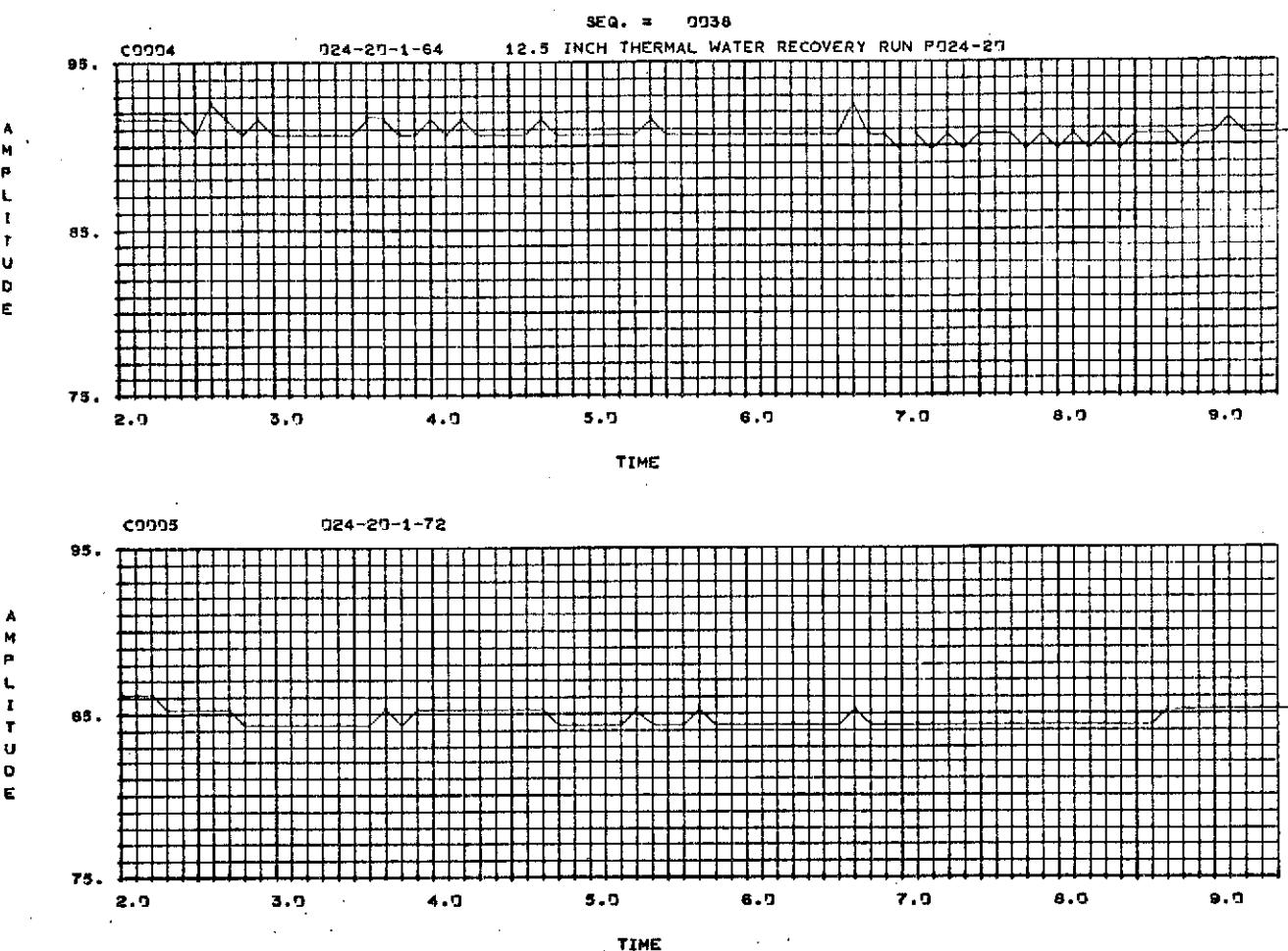


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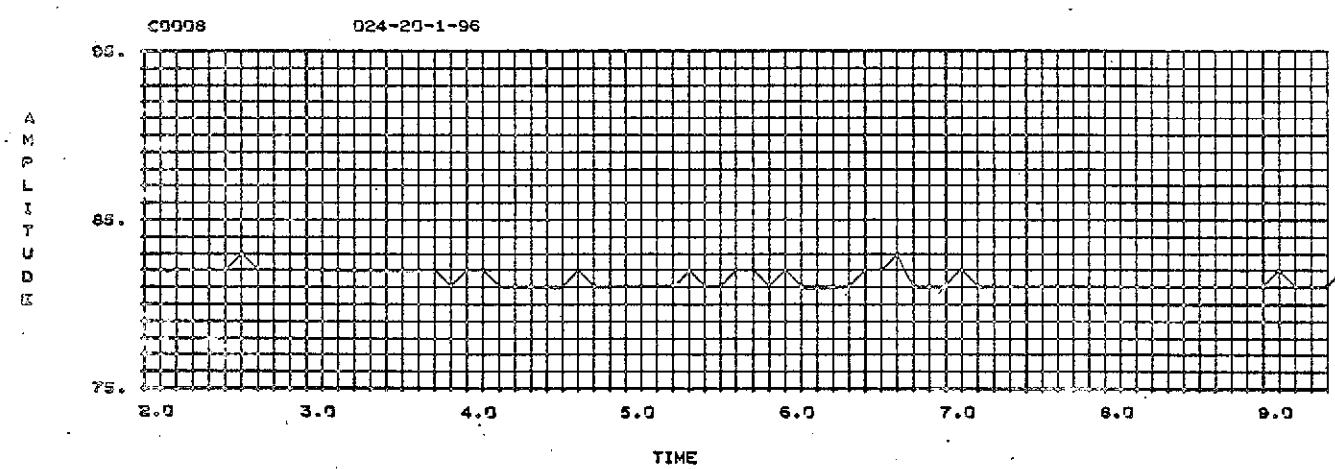
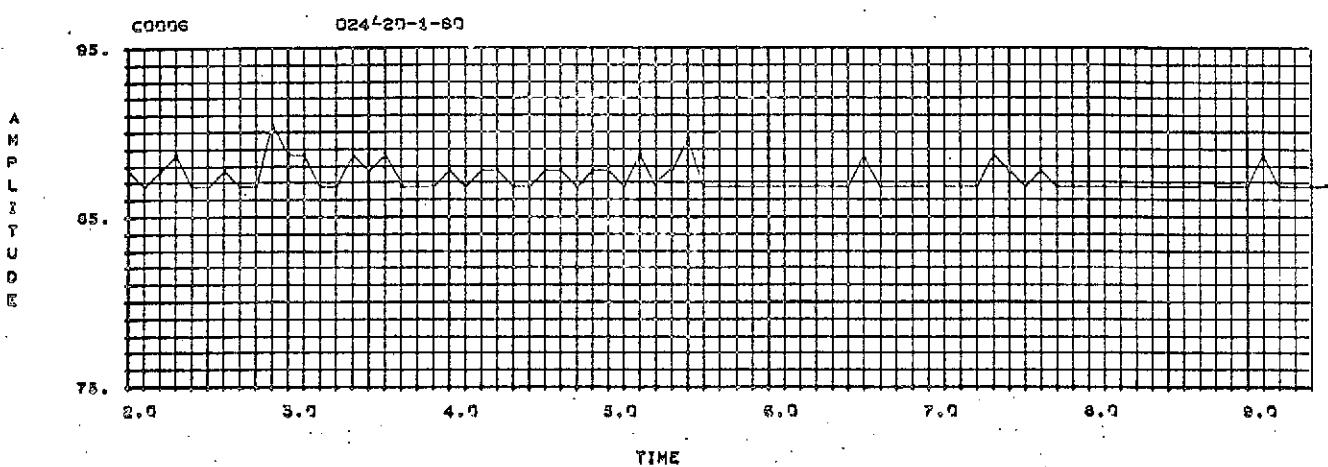


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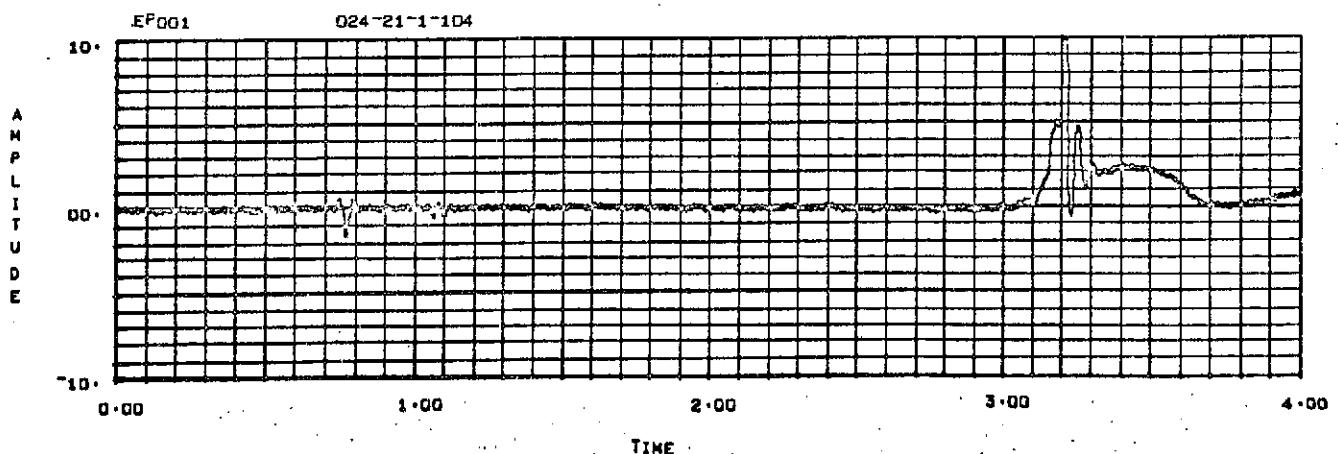
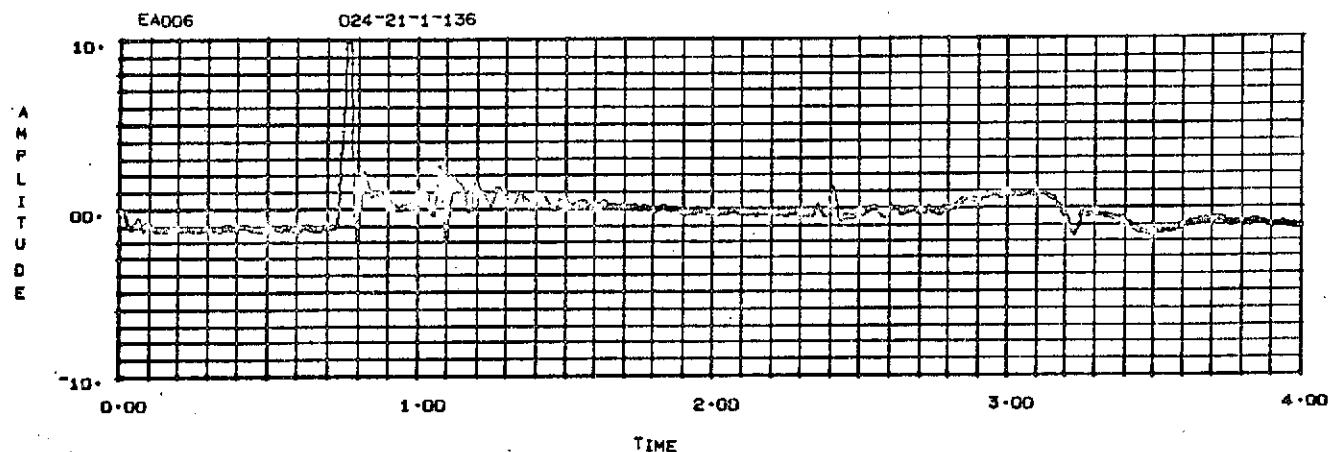
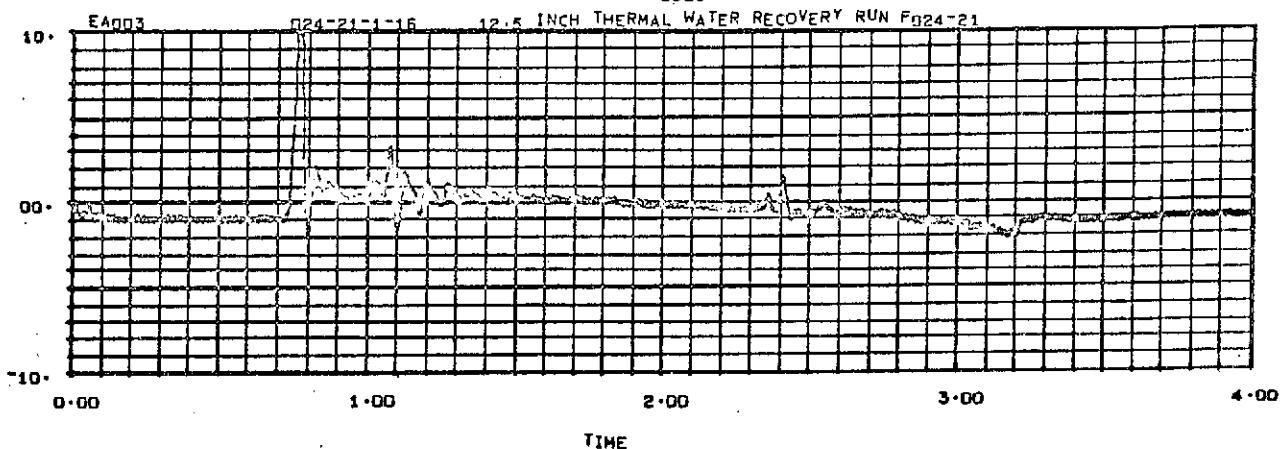




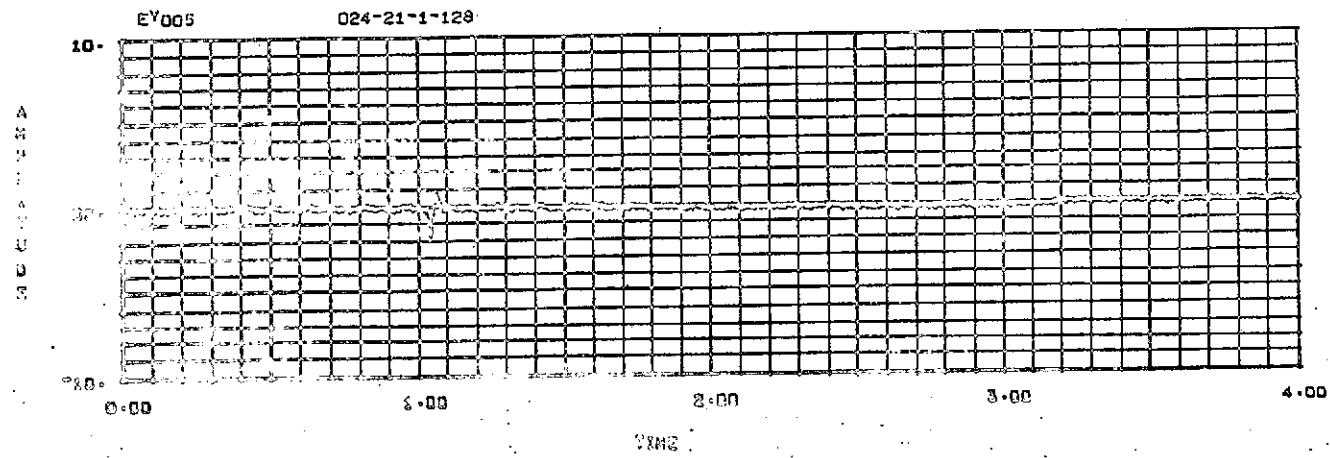
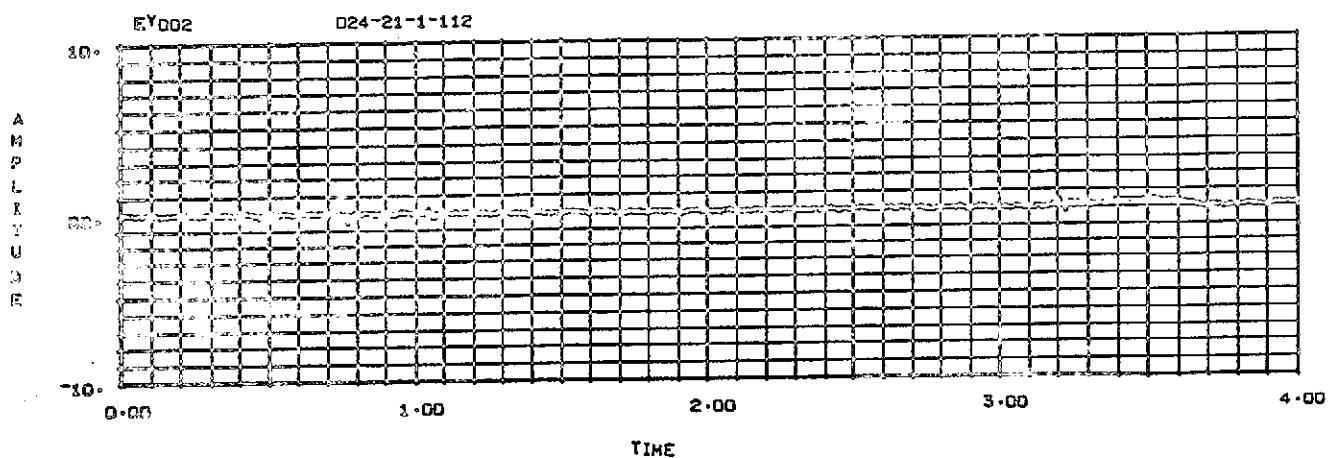
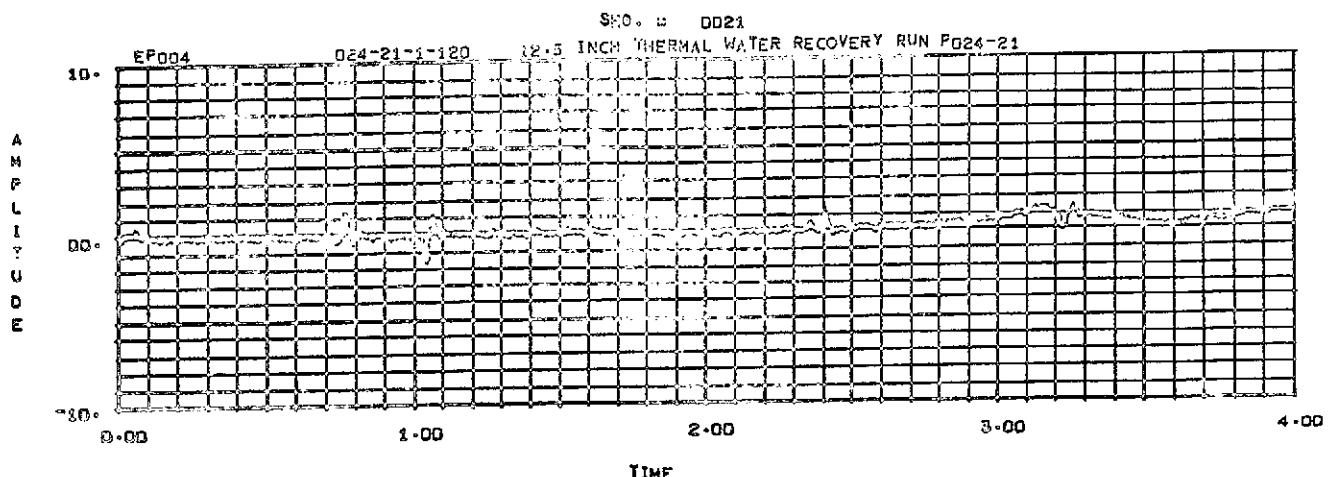
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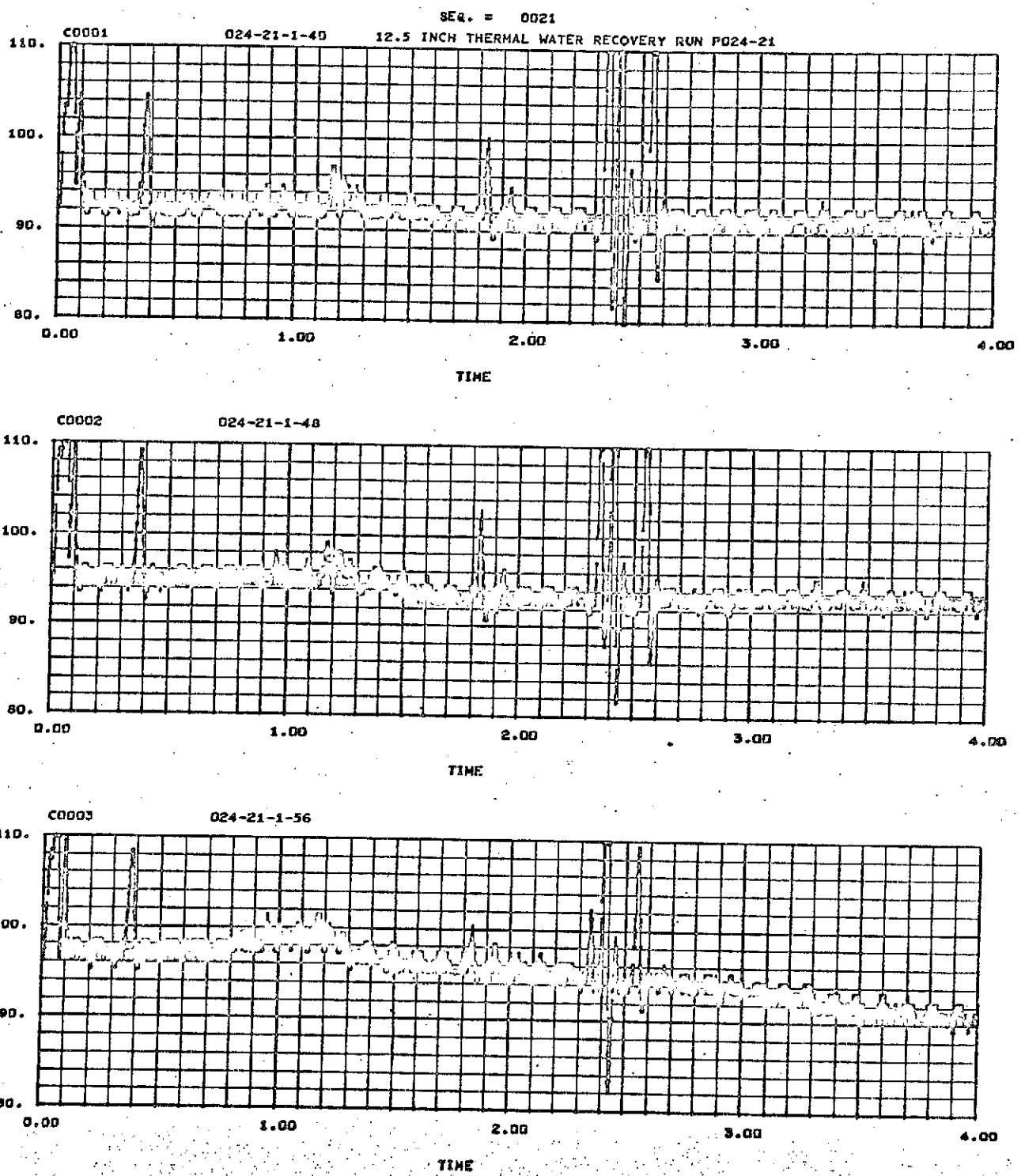


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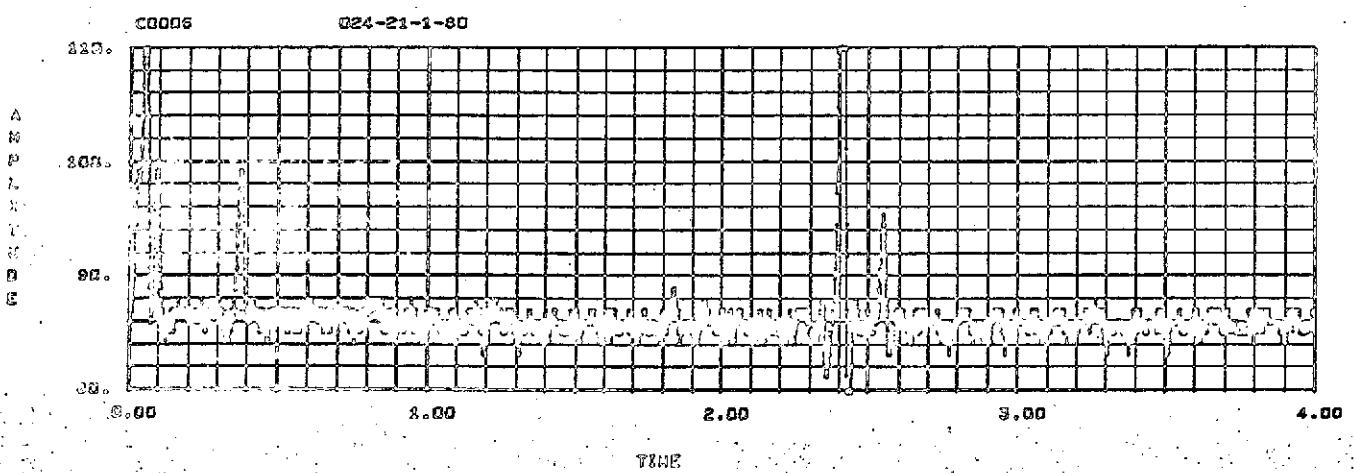
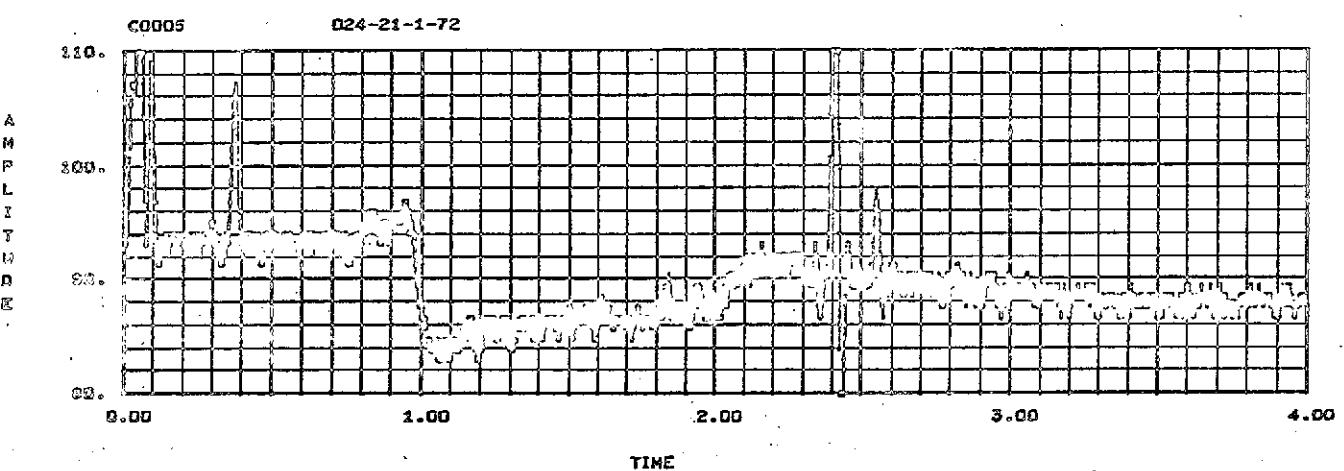
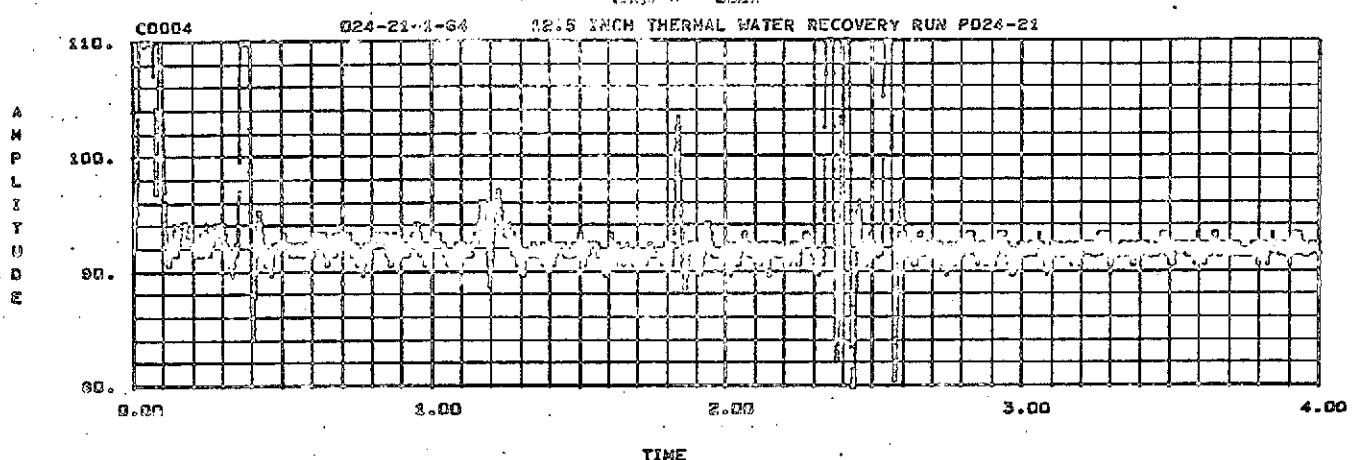
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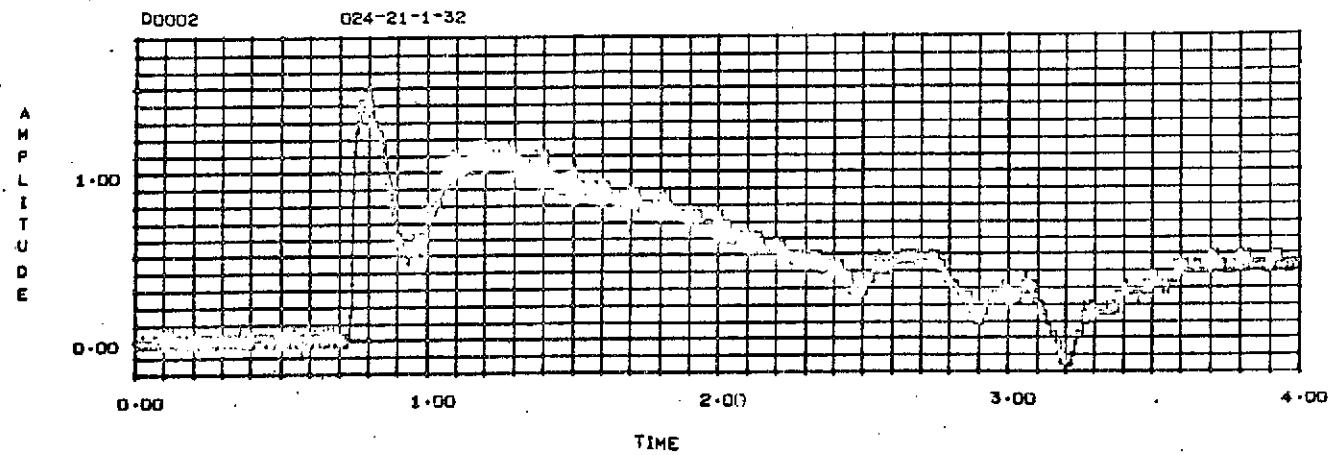
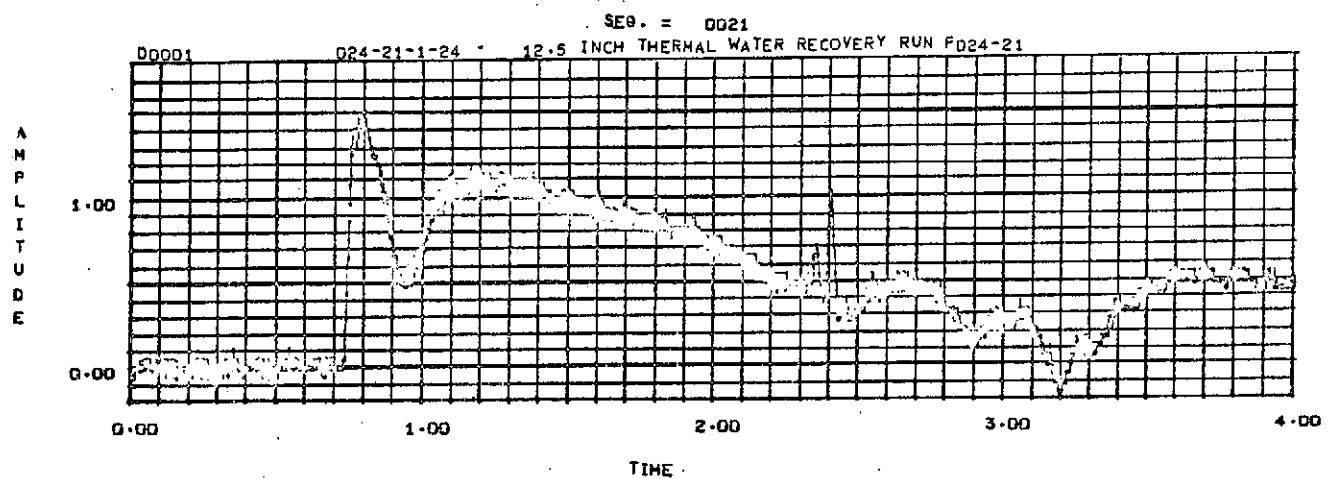
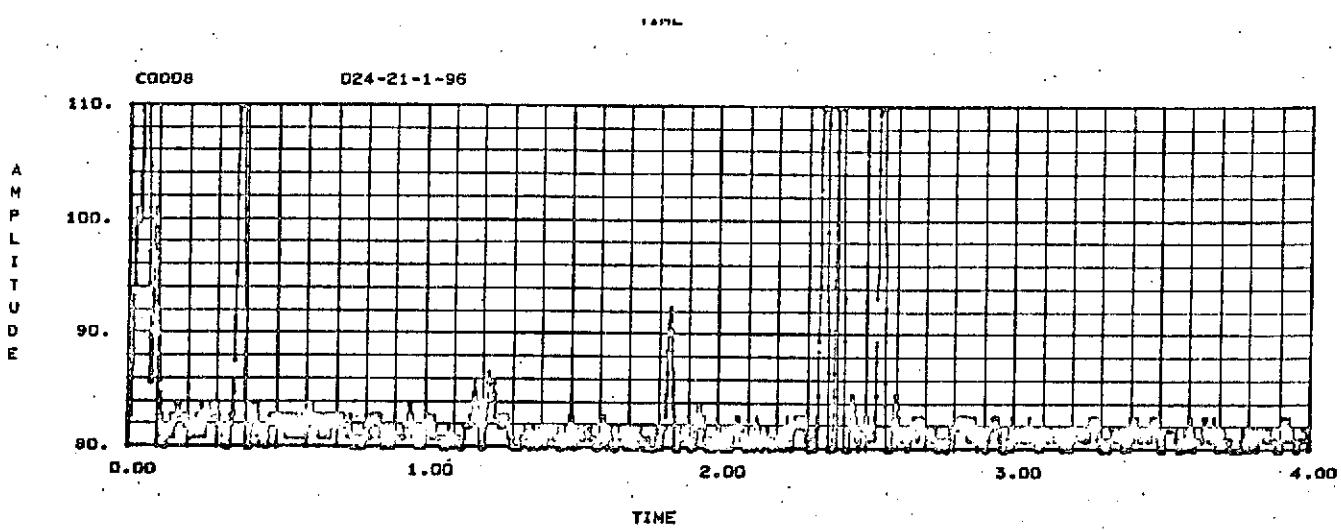


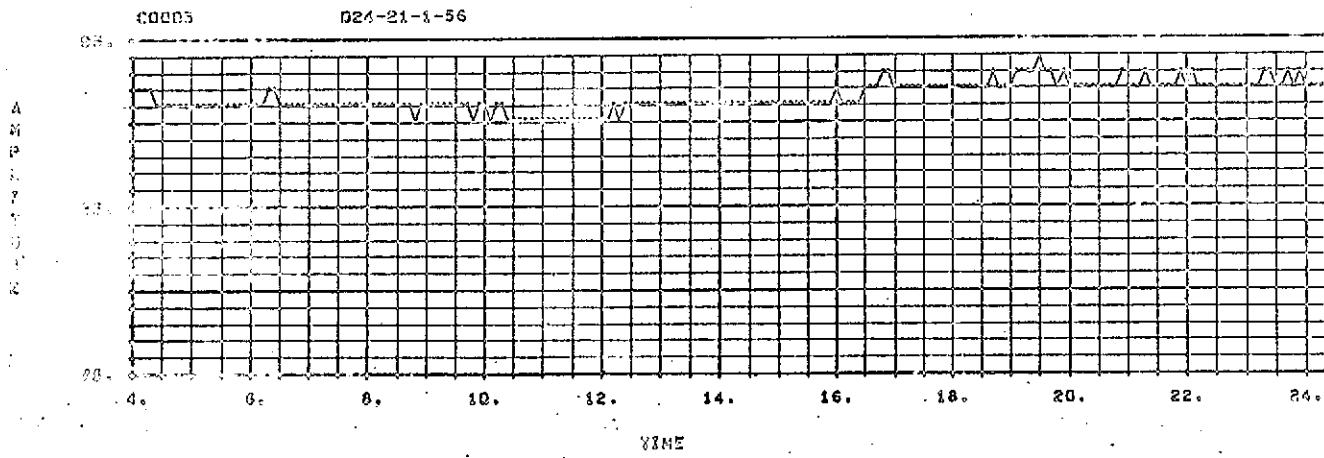
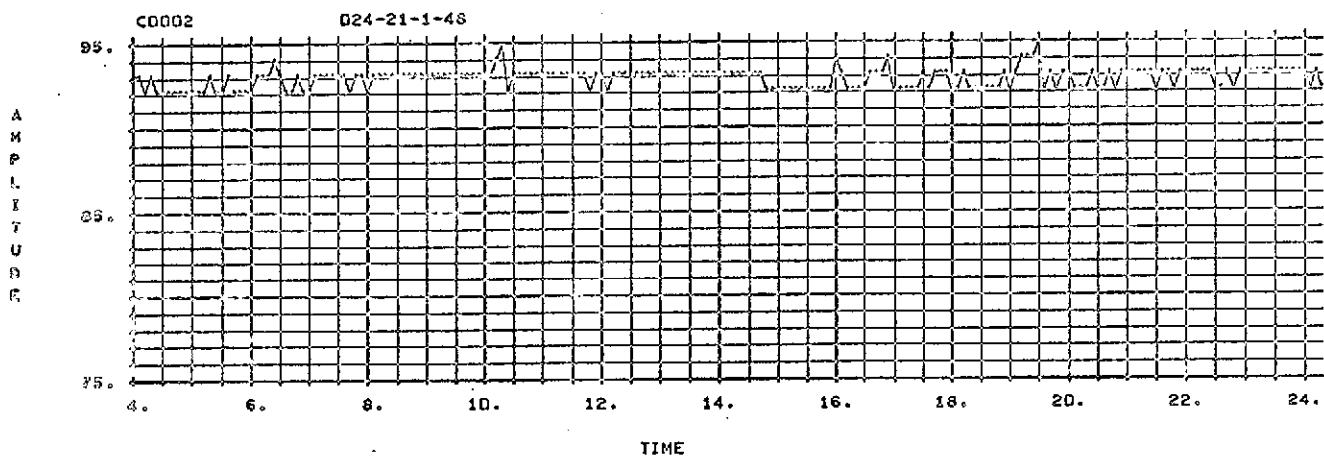
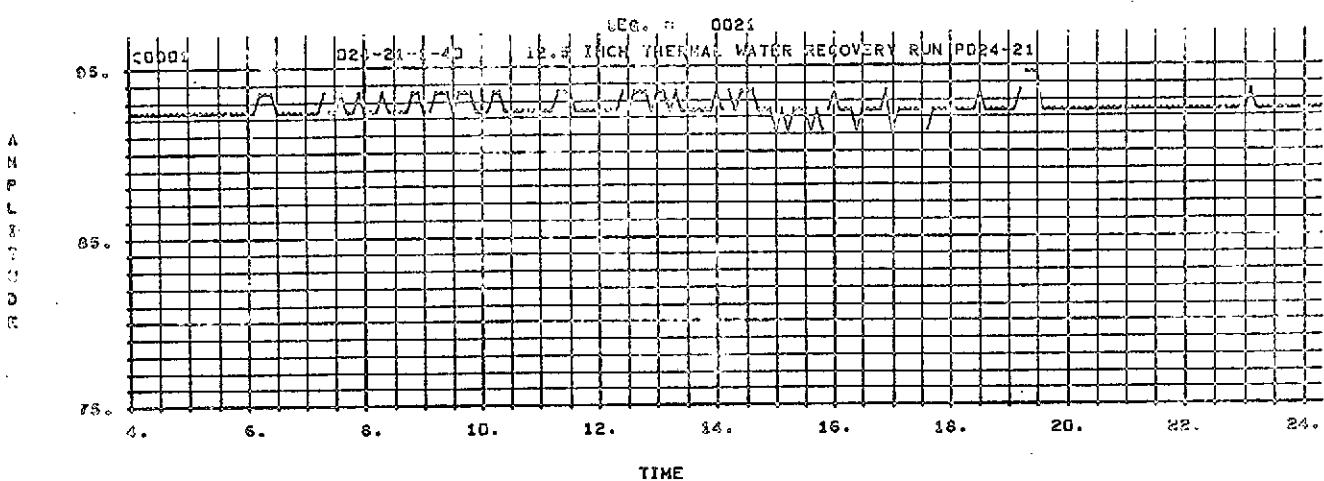


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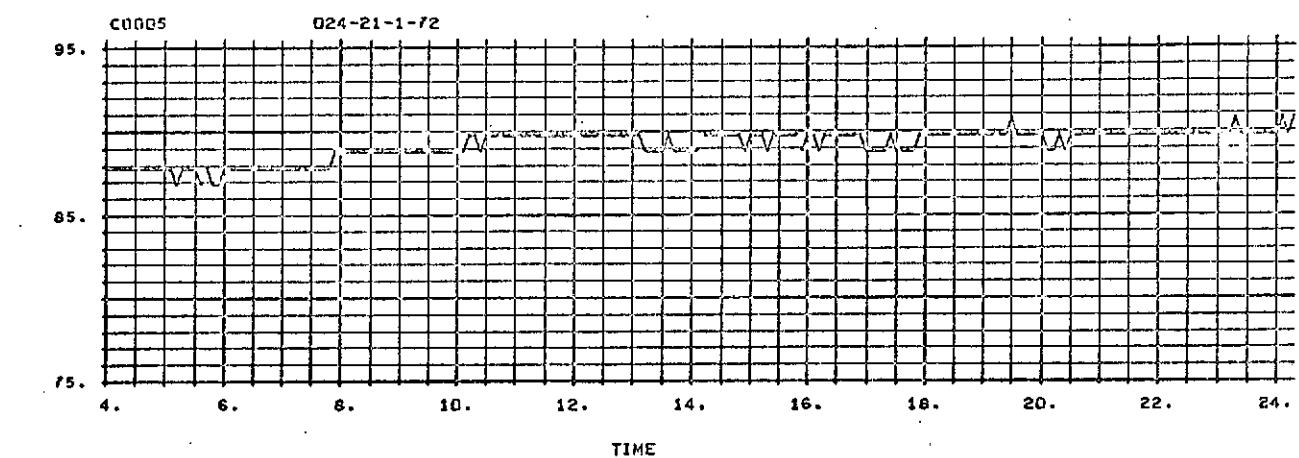
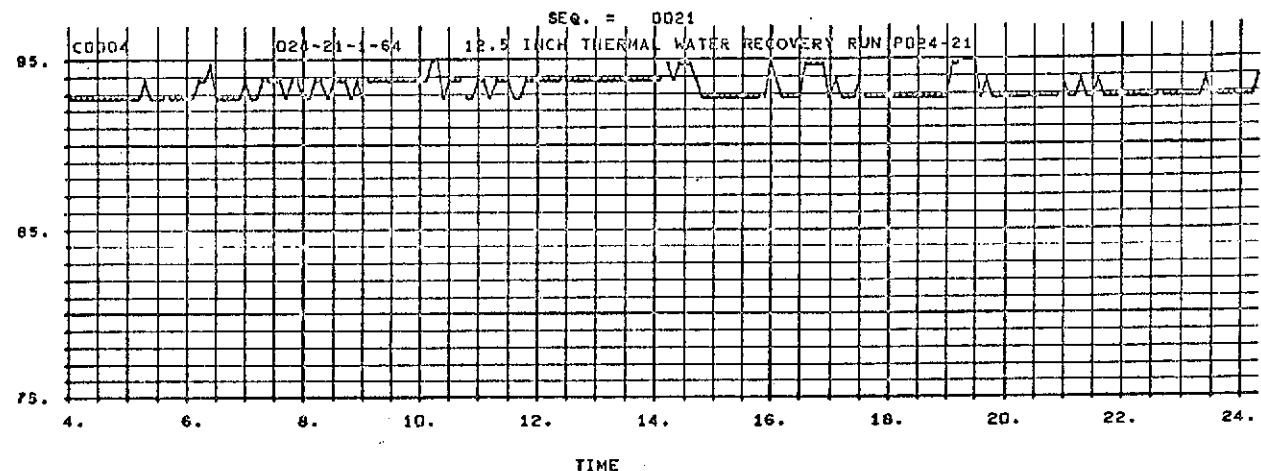
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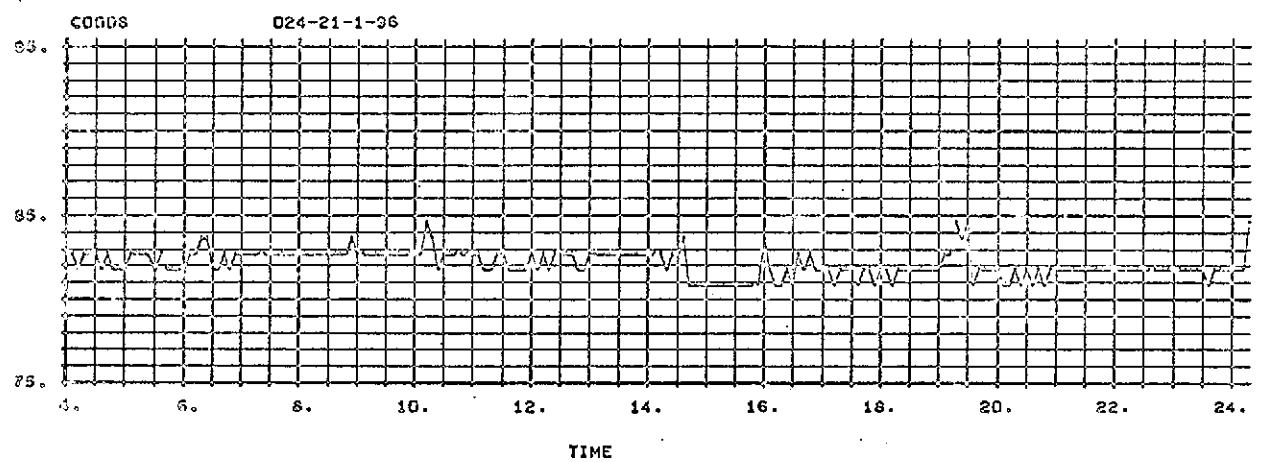
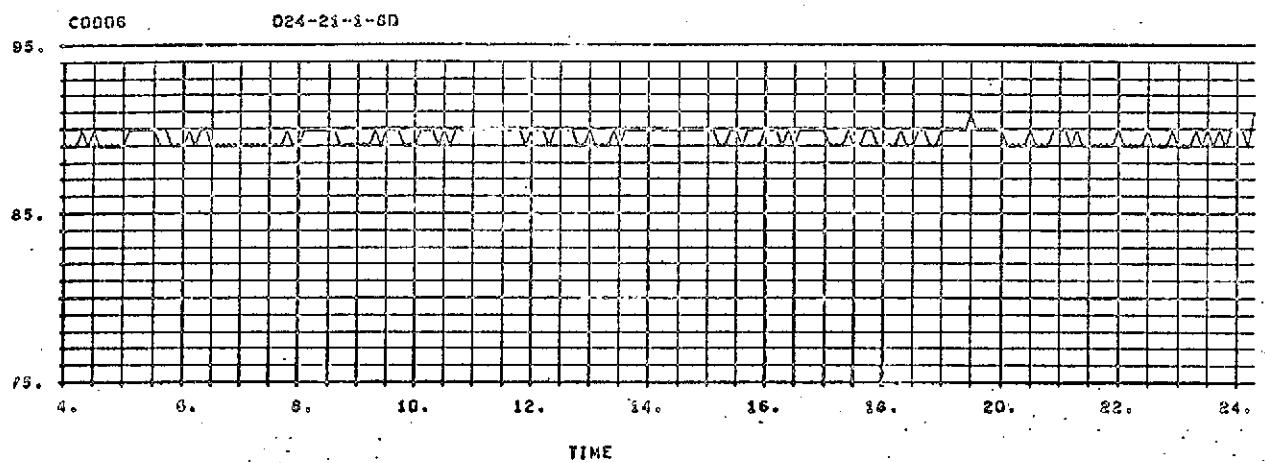


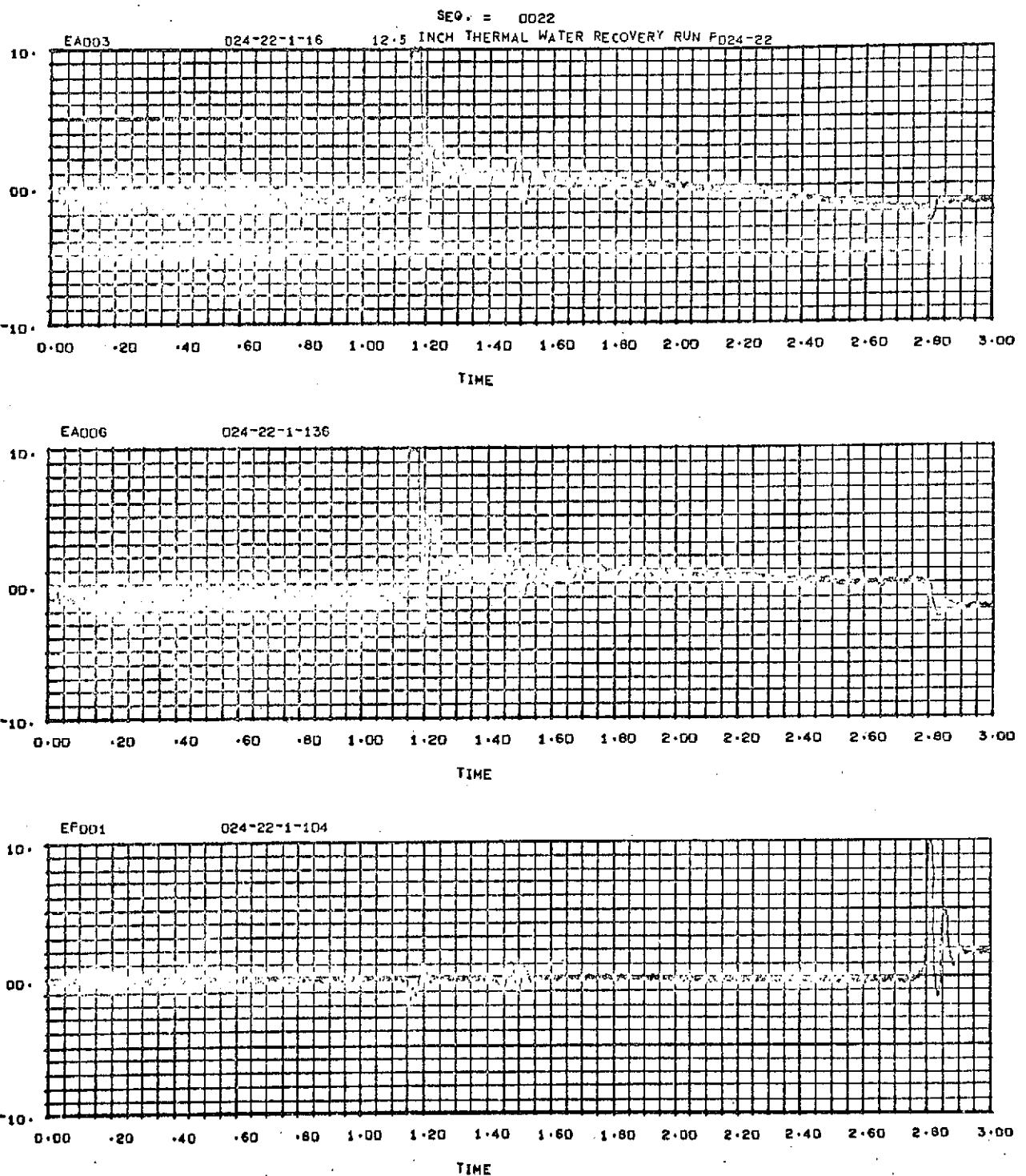


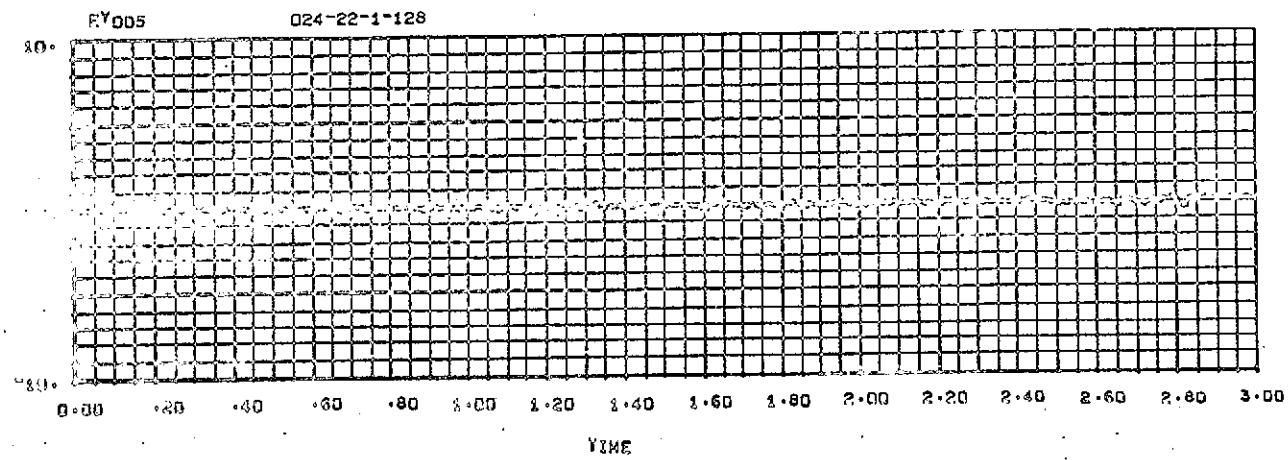
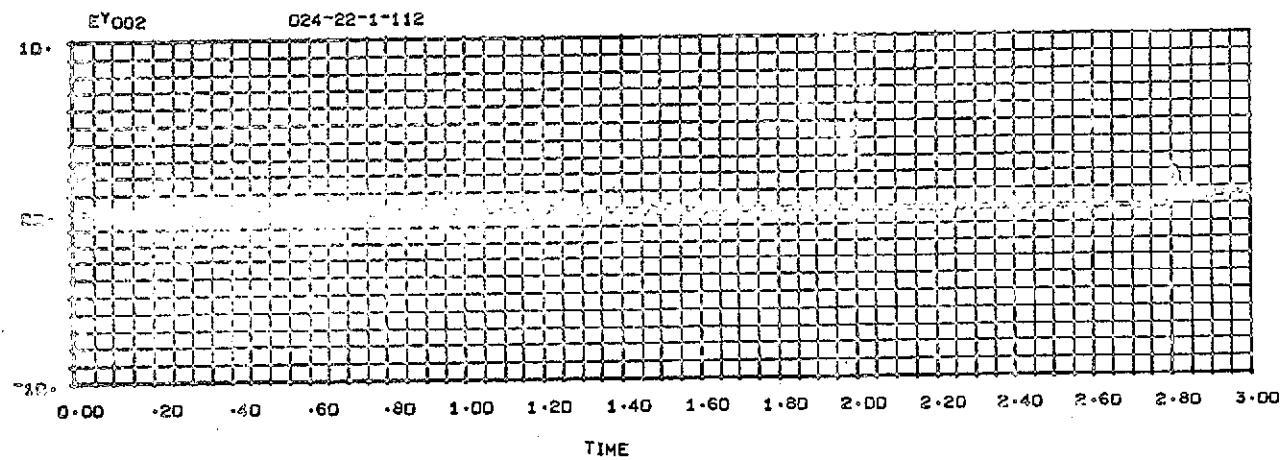
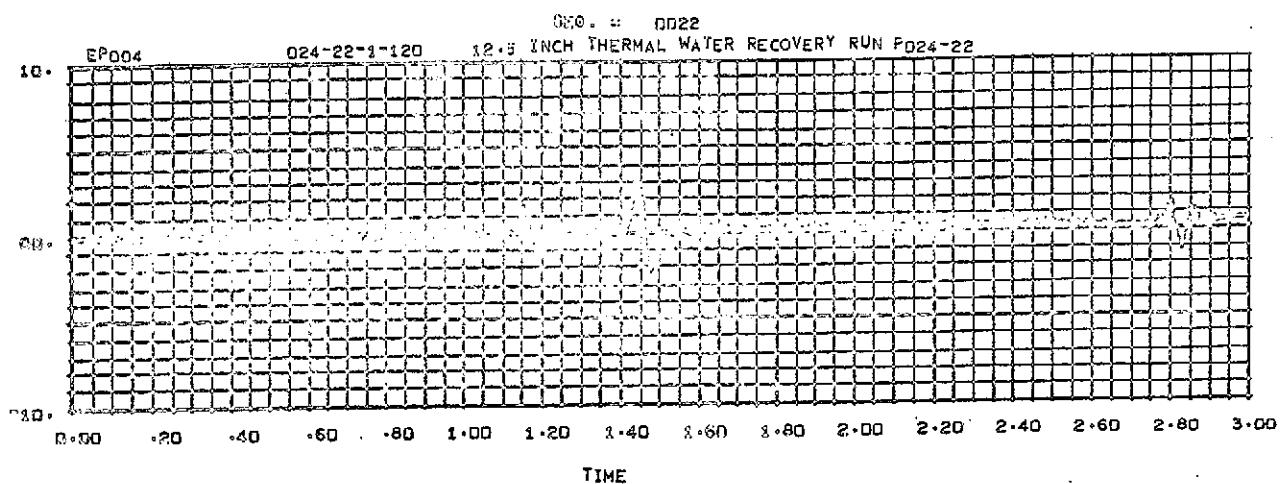


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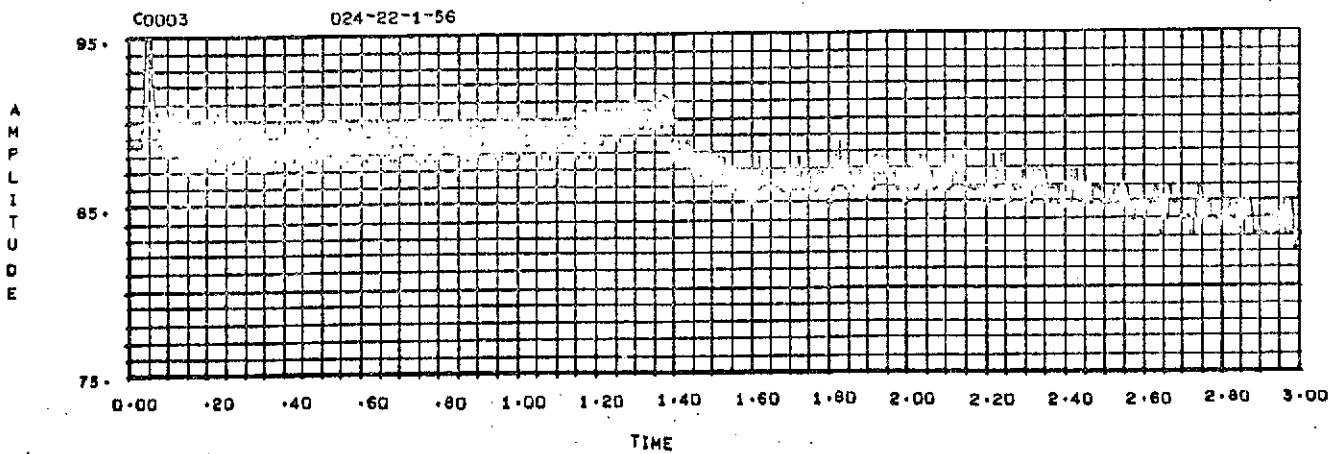
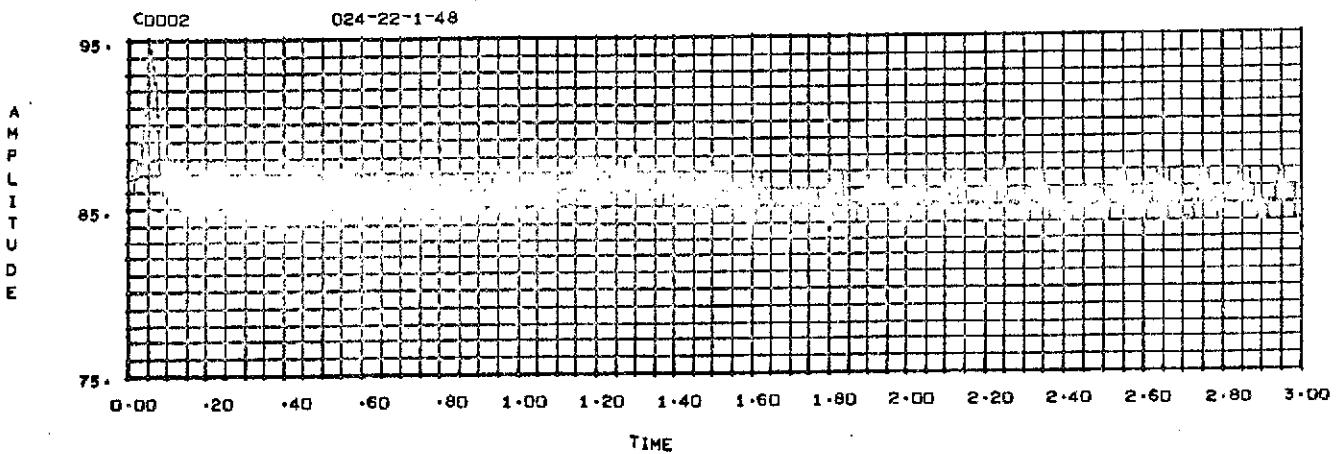
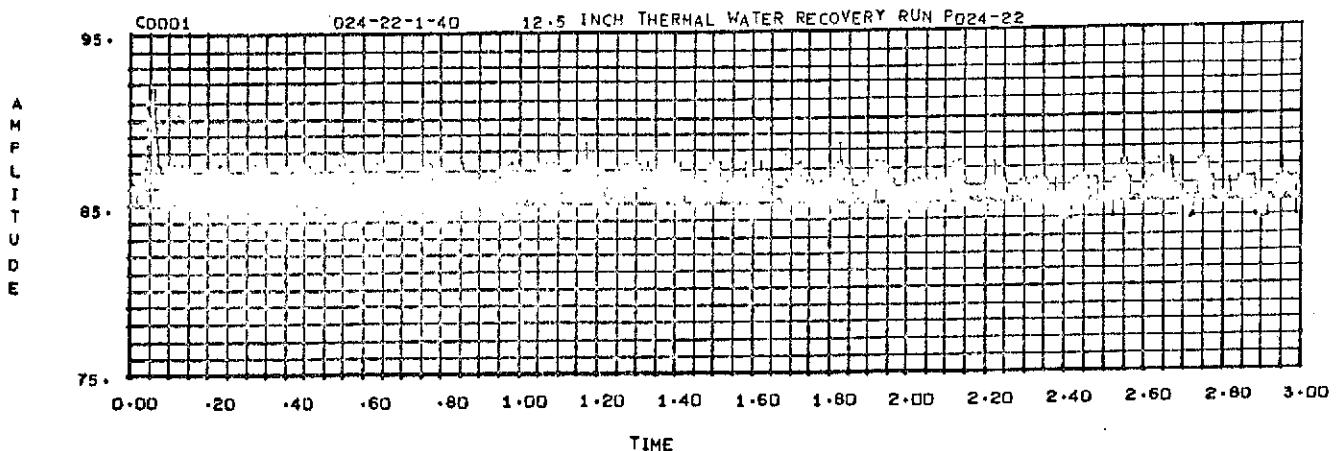




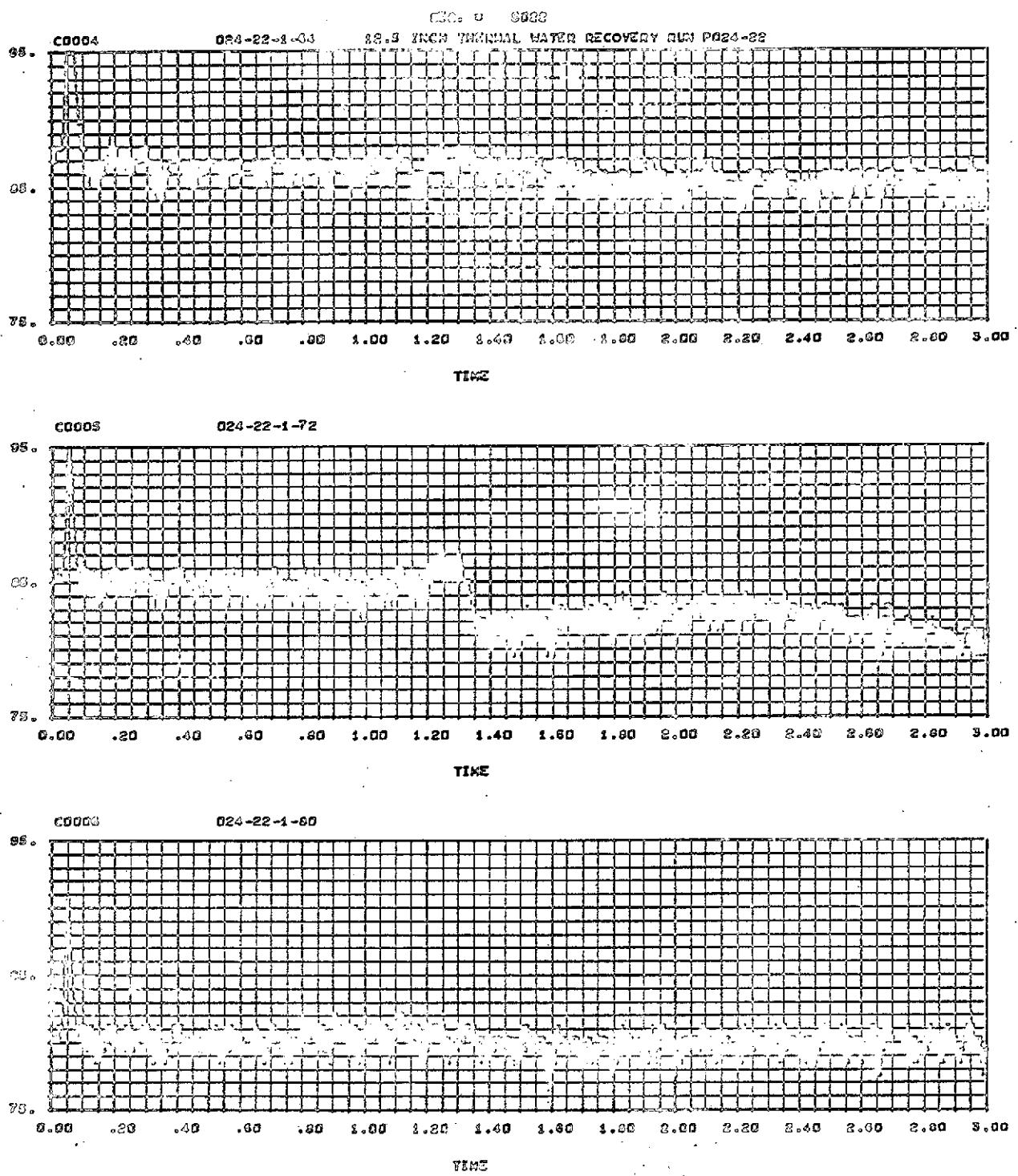




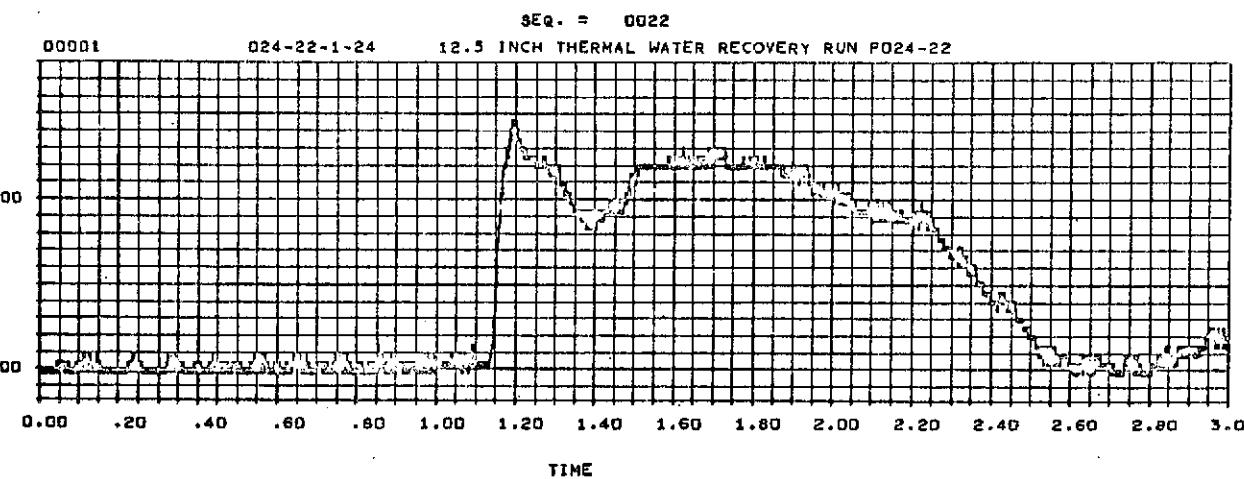
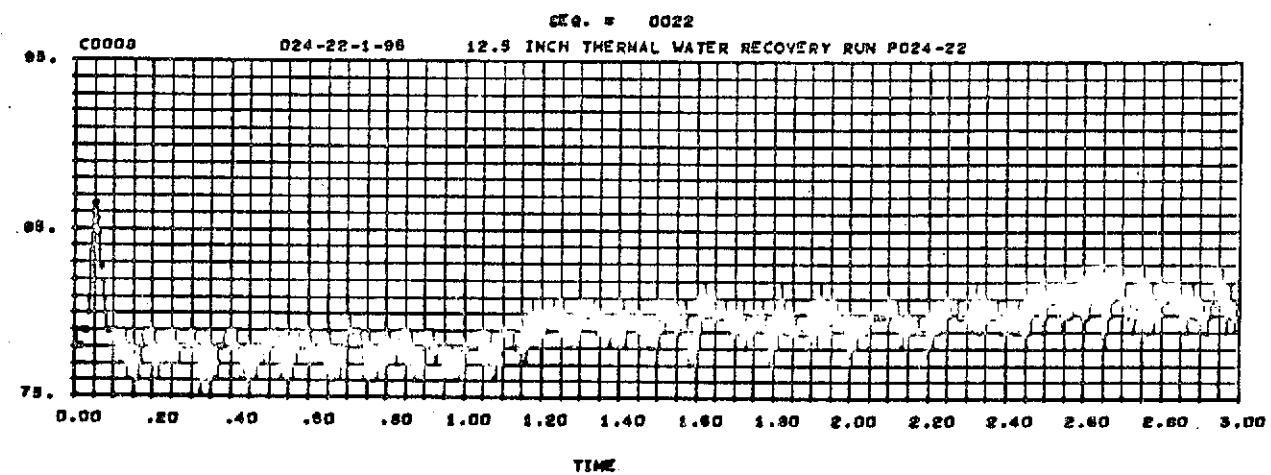
SEG. = 0022



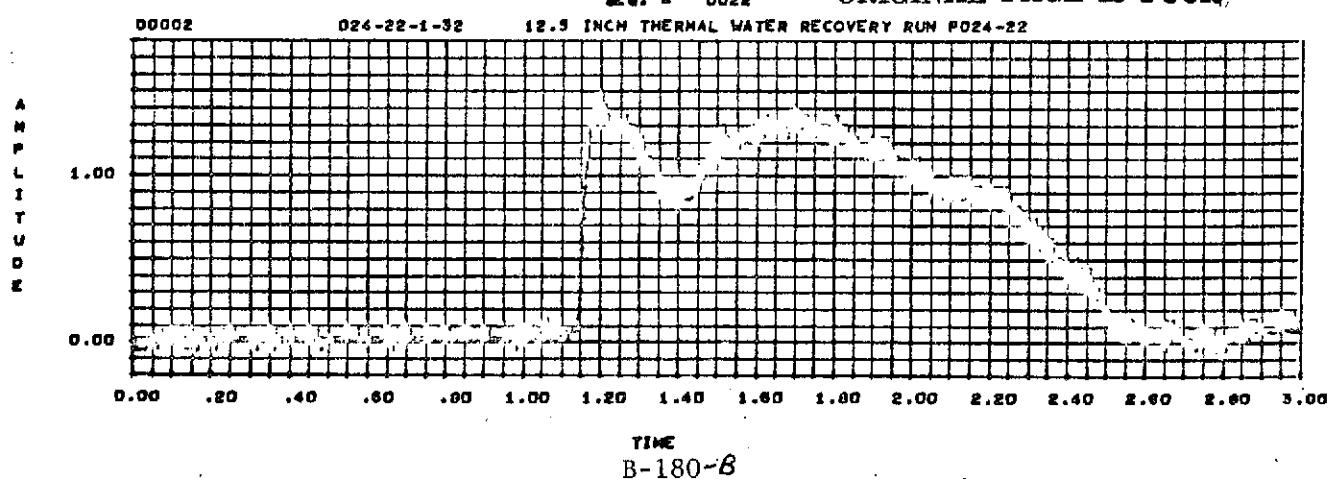
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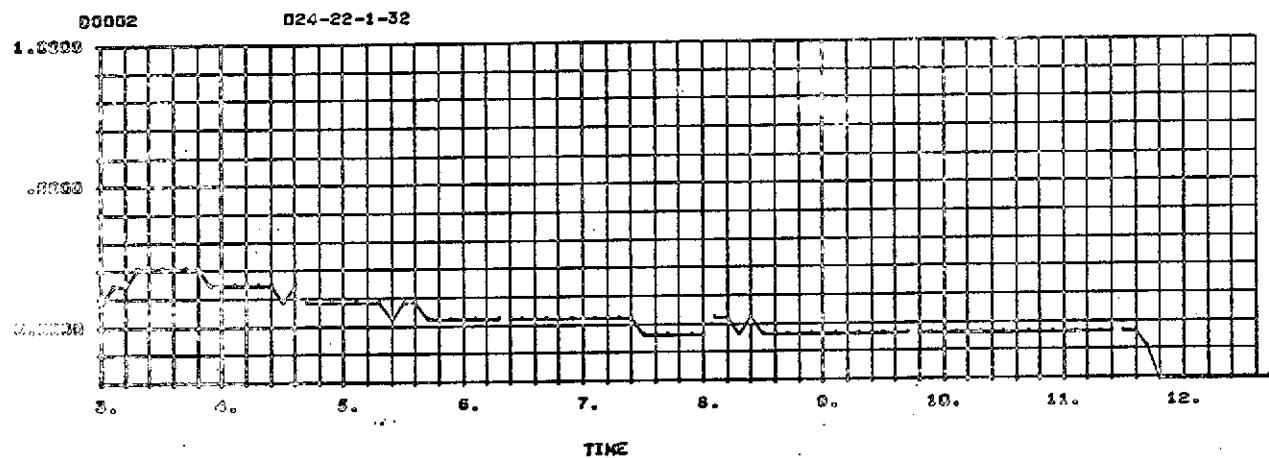
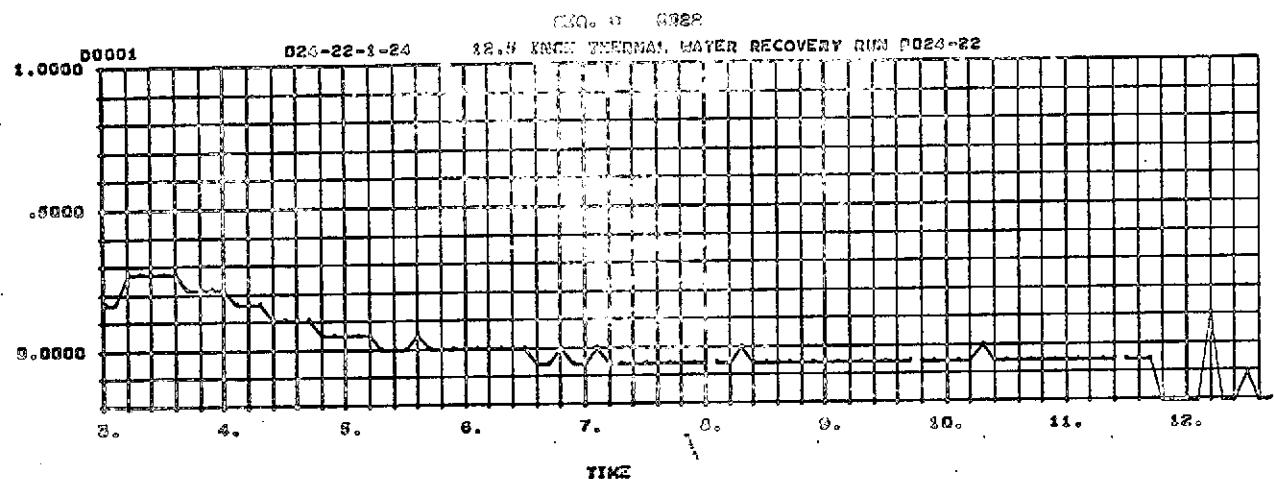


B-180A



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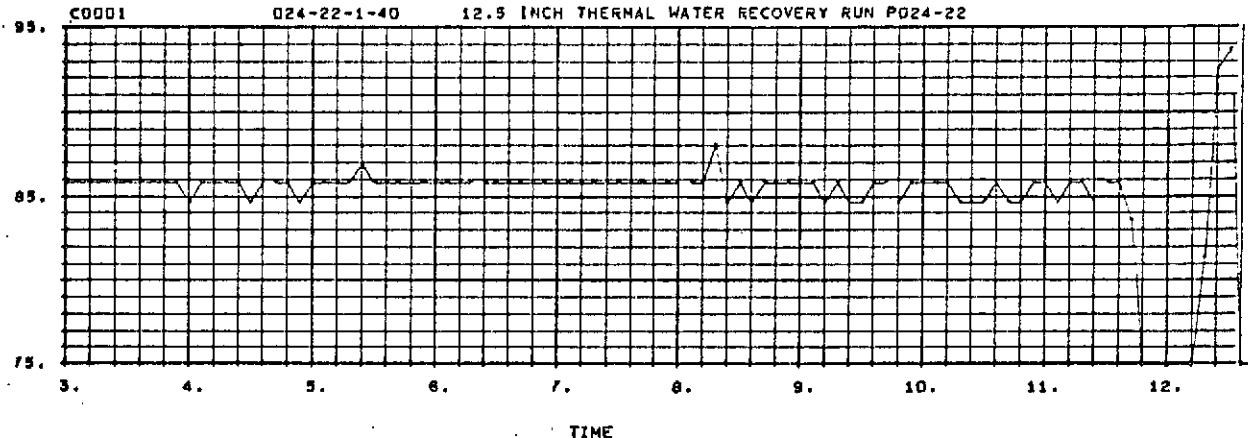
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C0001

024-22-1-40

12.5 INCH THERMAL WATER RECOVERY RUN P024-22

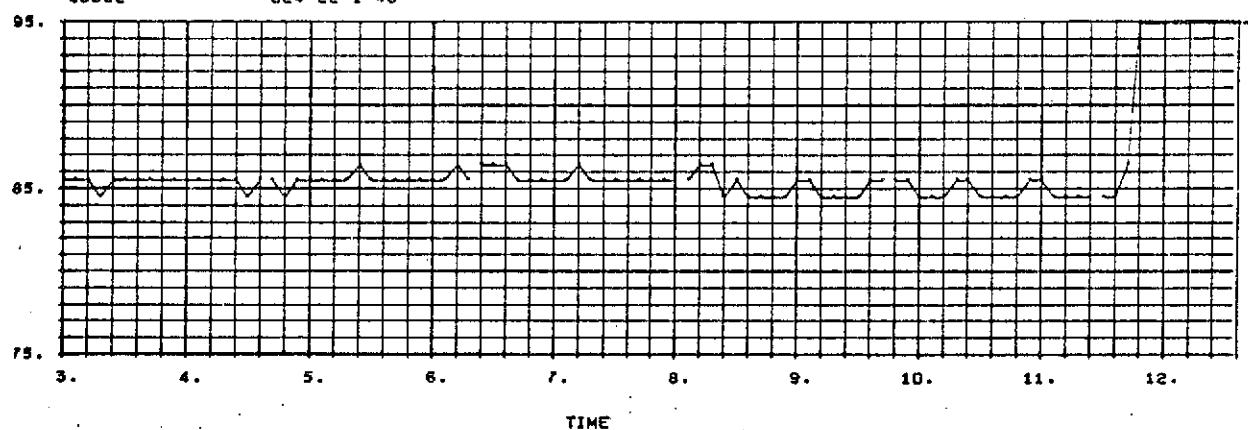
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C0002

024-22-1-48

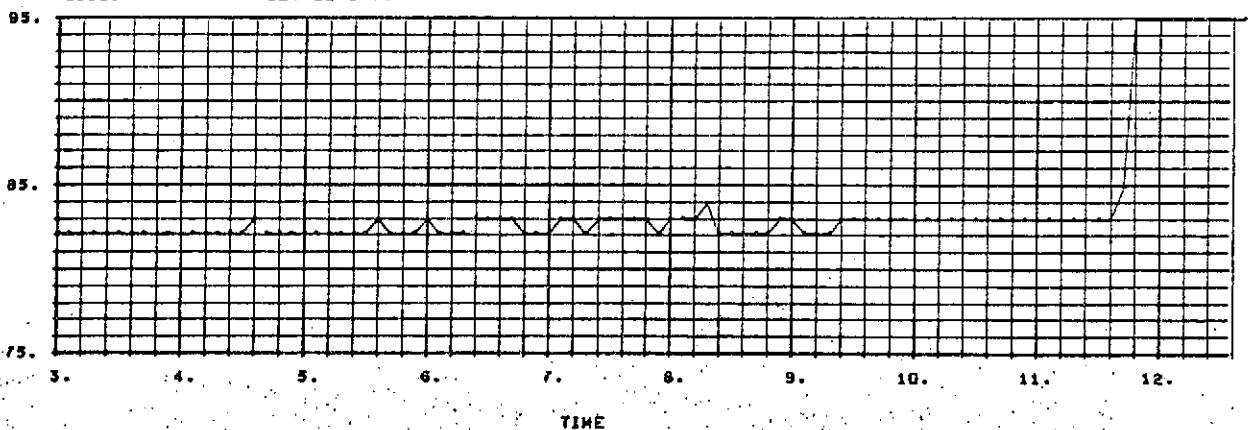
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C0003

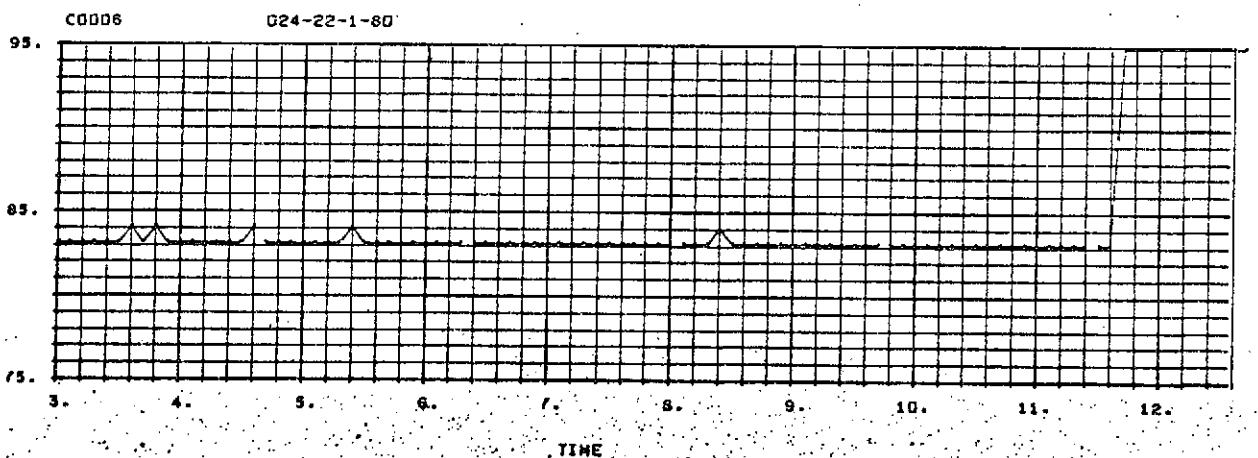
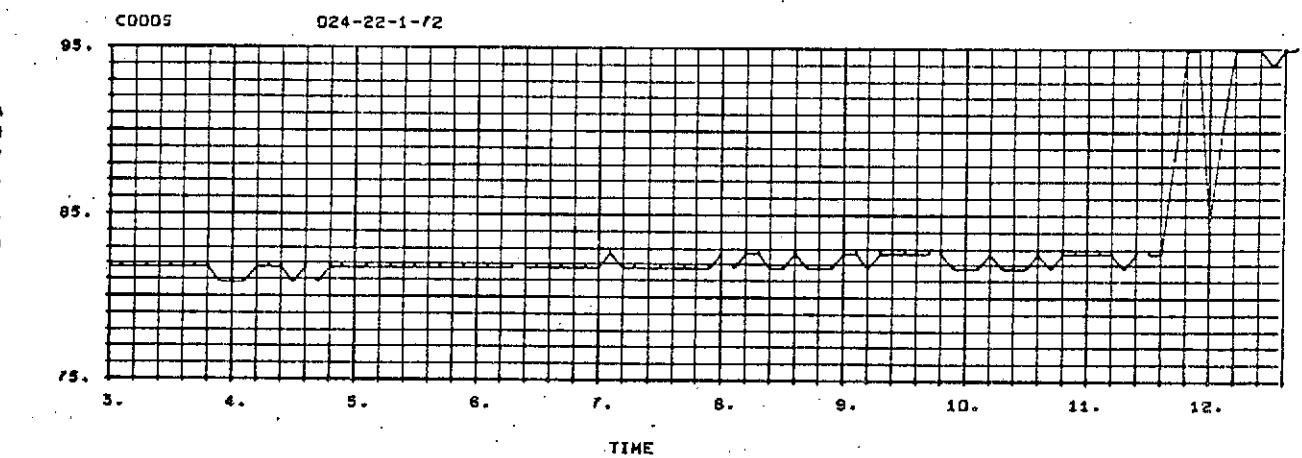
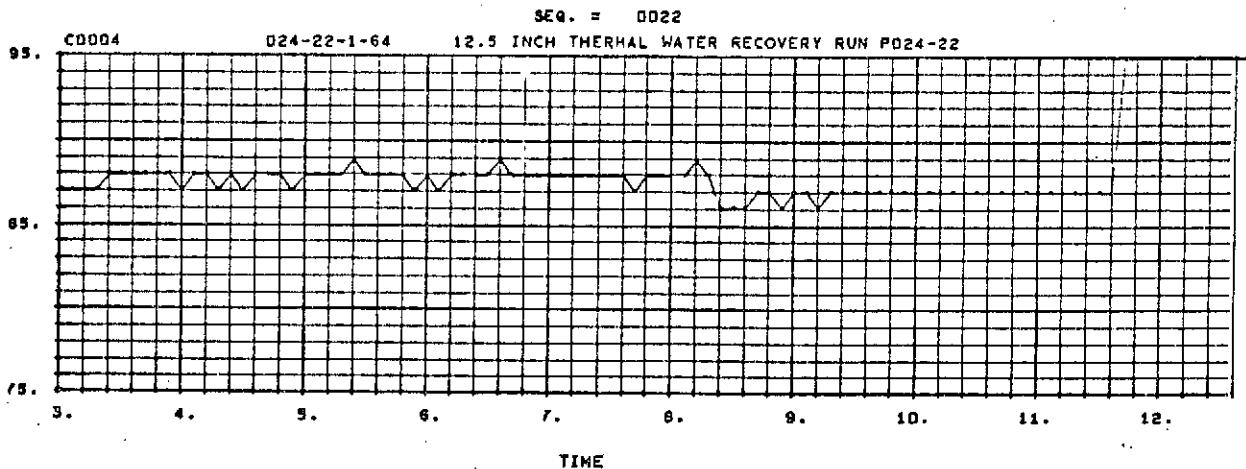
024-22-1-56

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B-182



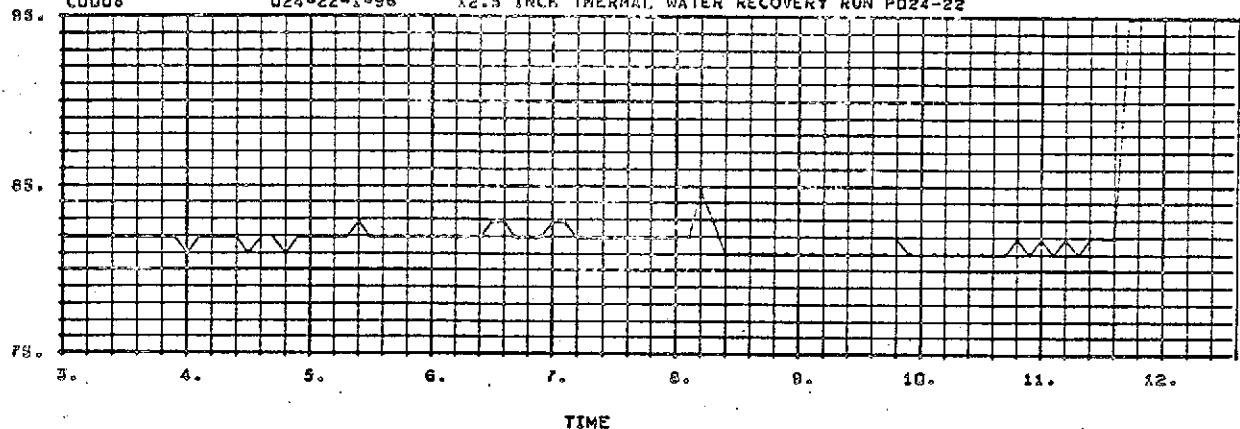
B-183 REPRODUCIBILITY OF THE
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800. 0 8022

024-22-1-96

12.5 INCH THERMAL WATER RECOVERY RUN P024-22

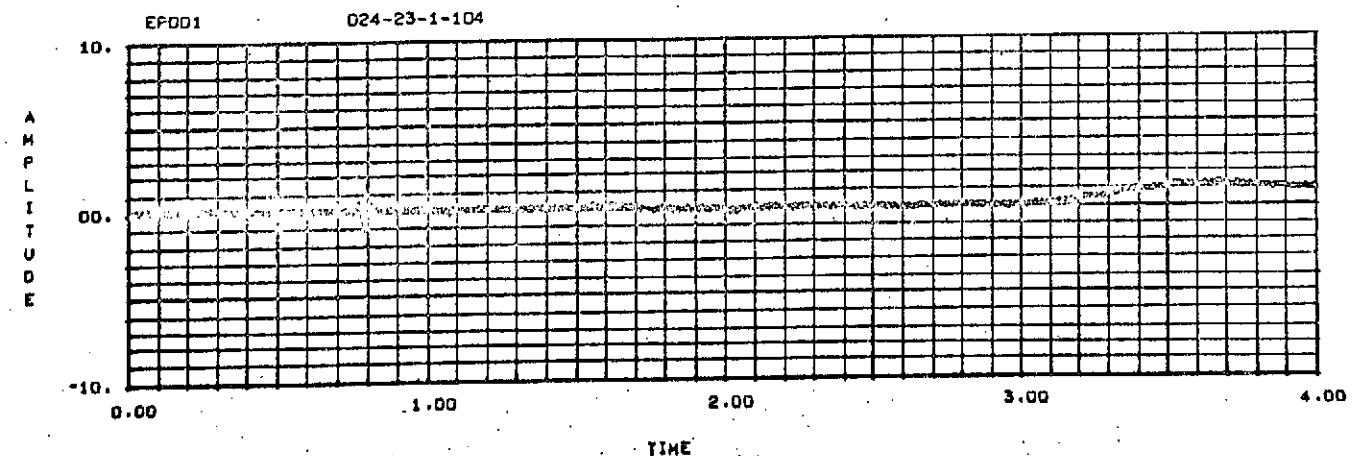
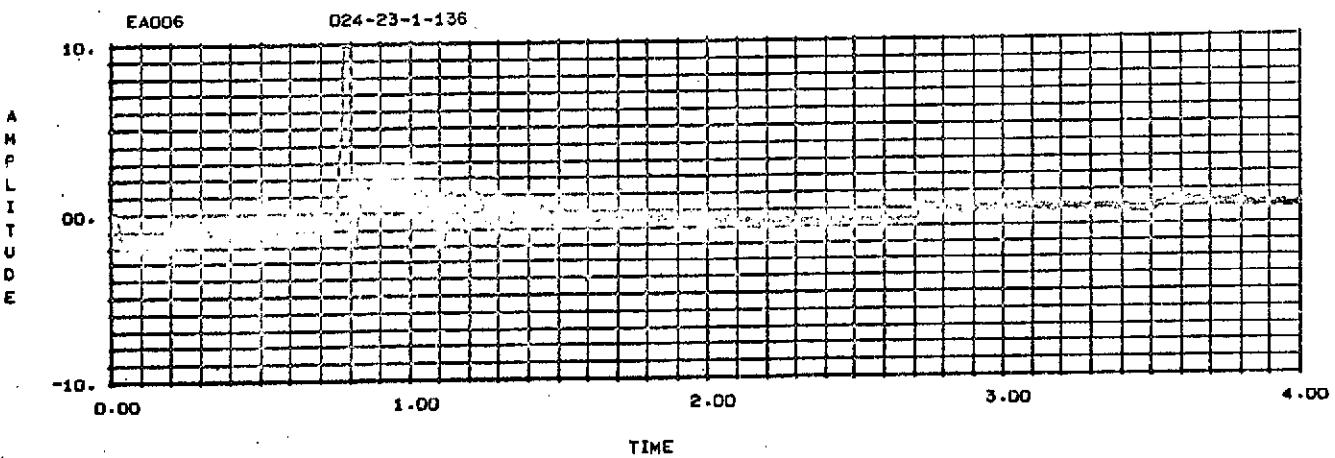
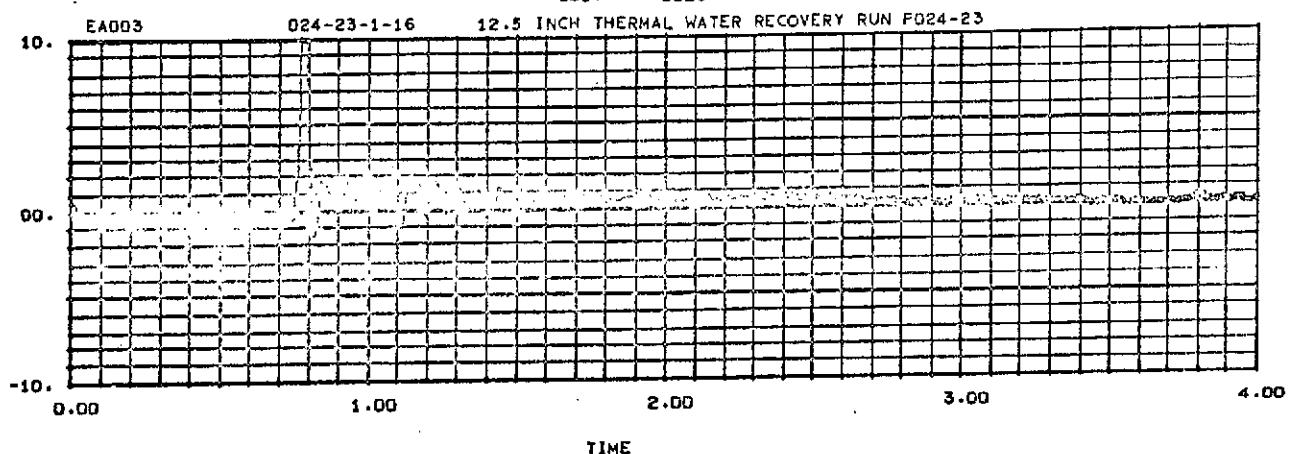
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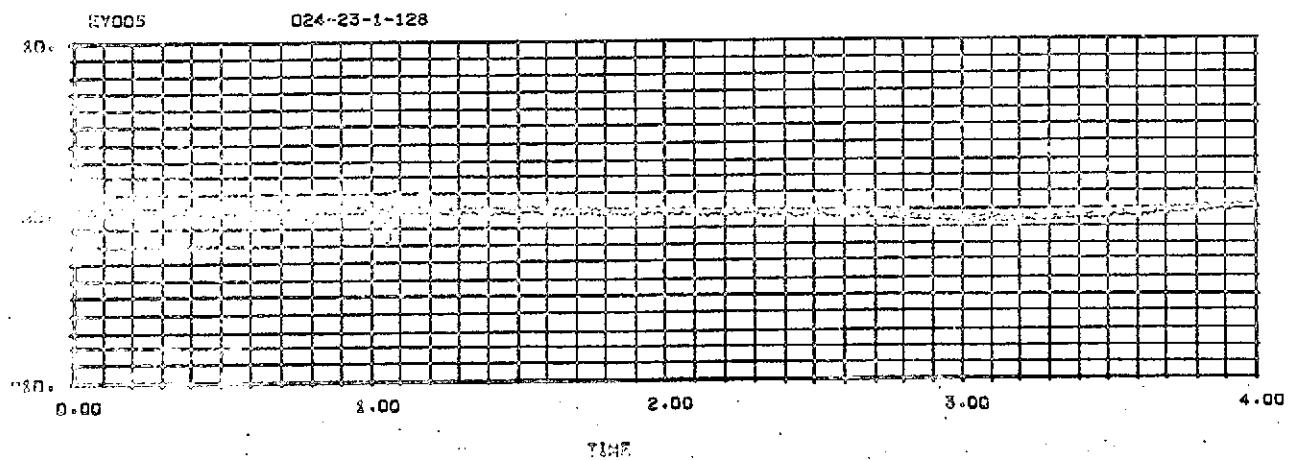
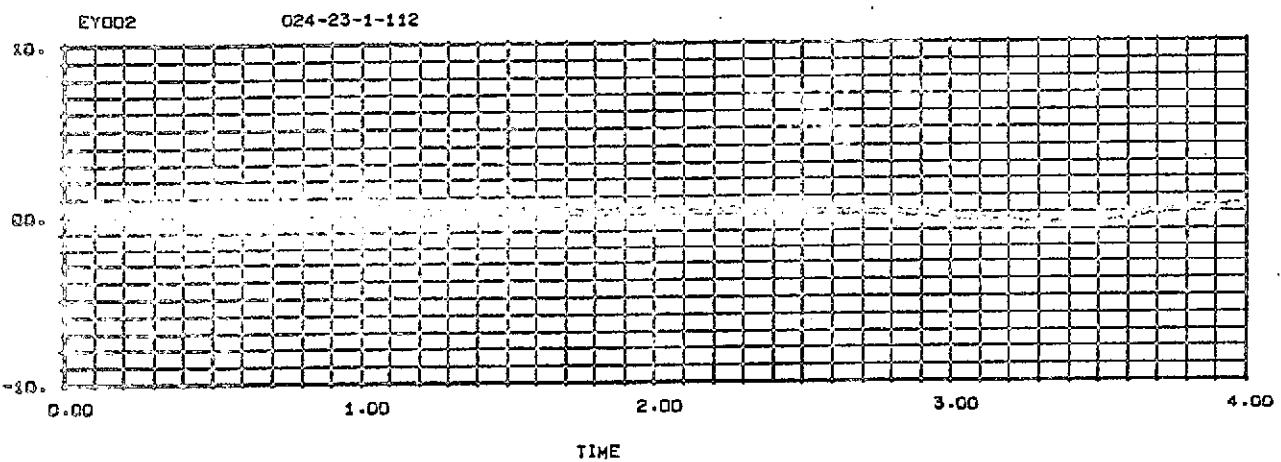
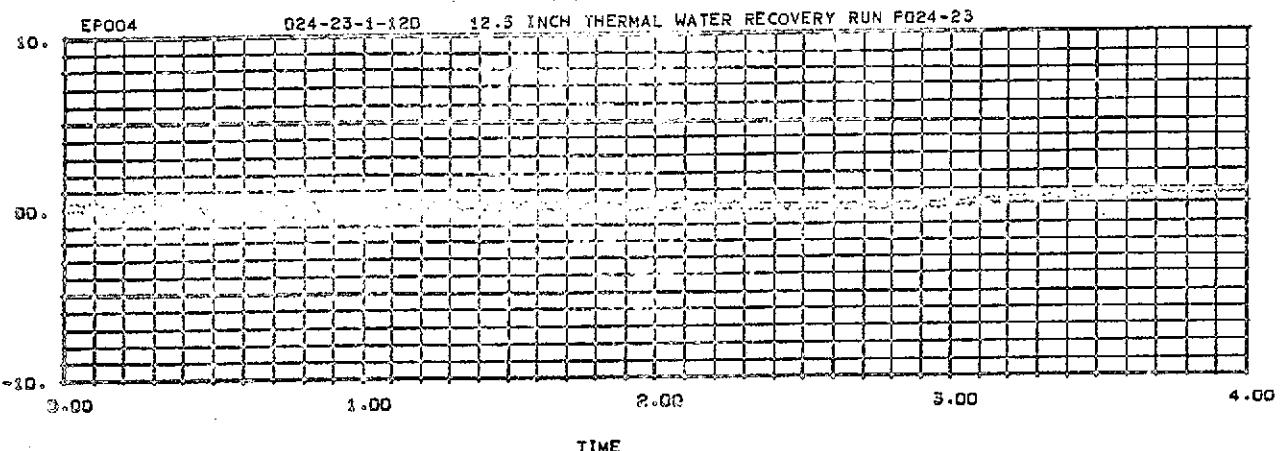
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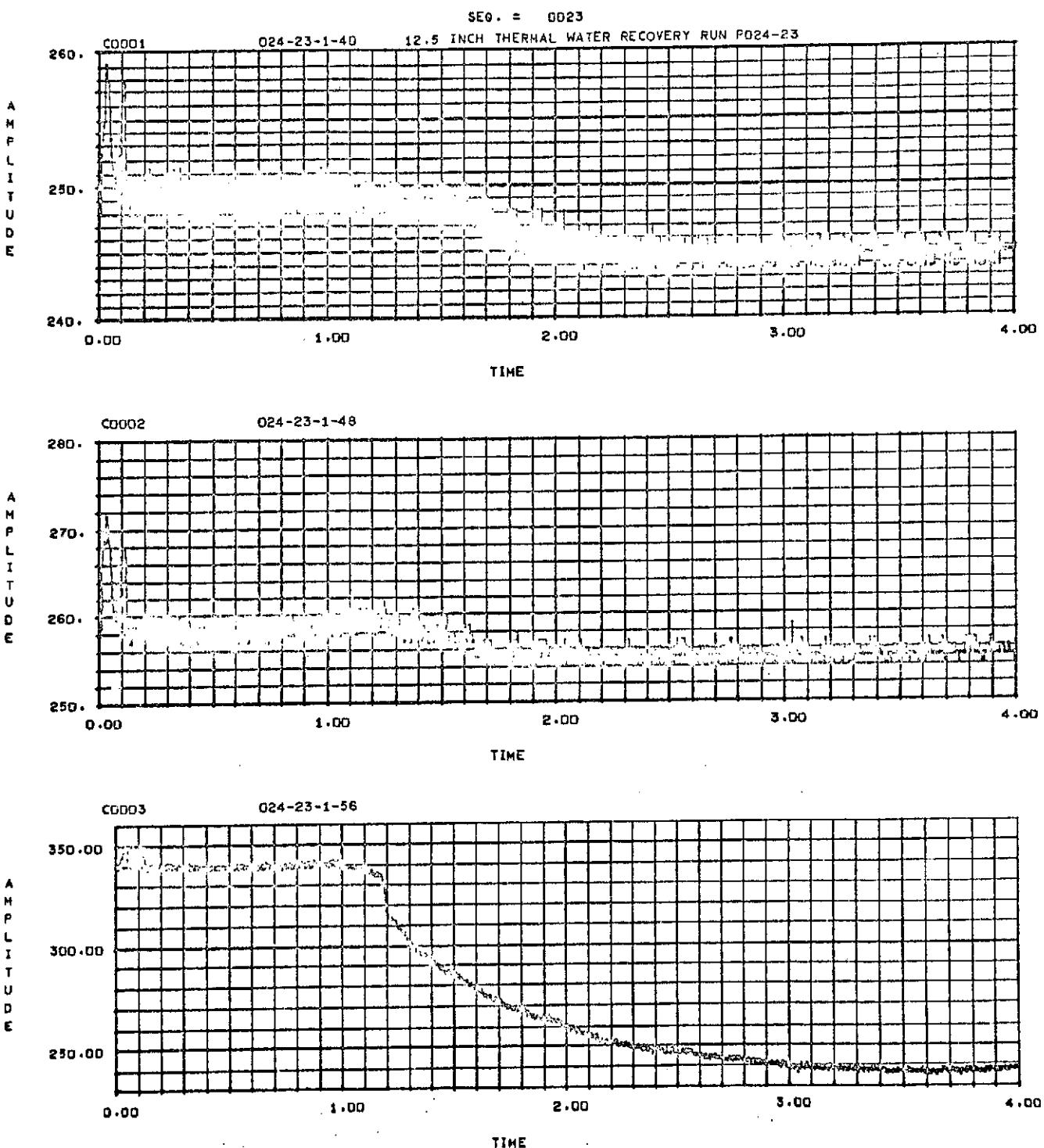
B-184

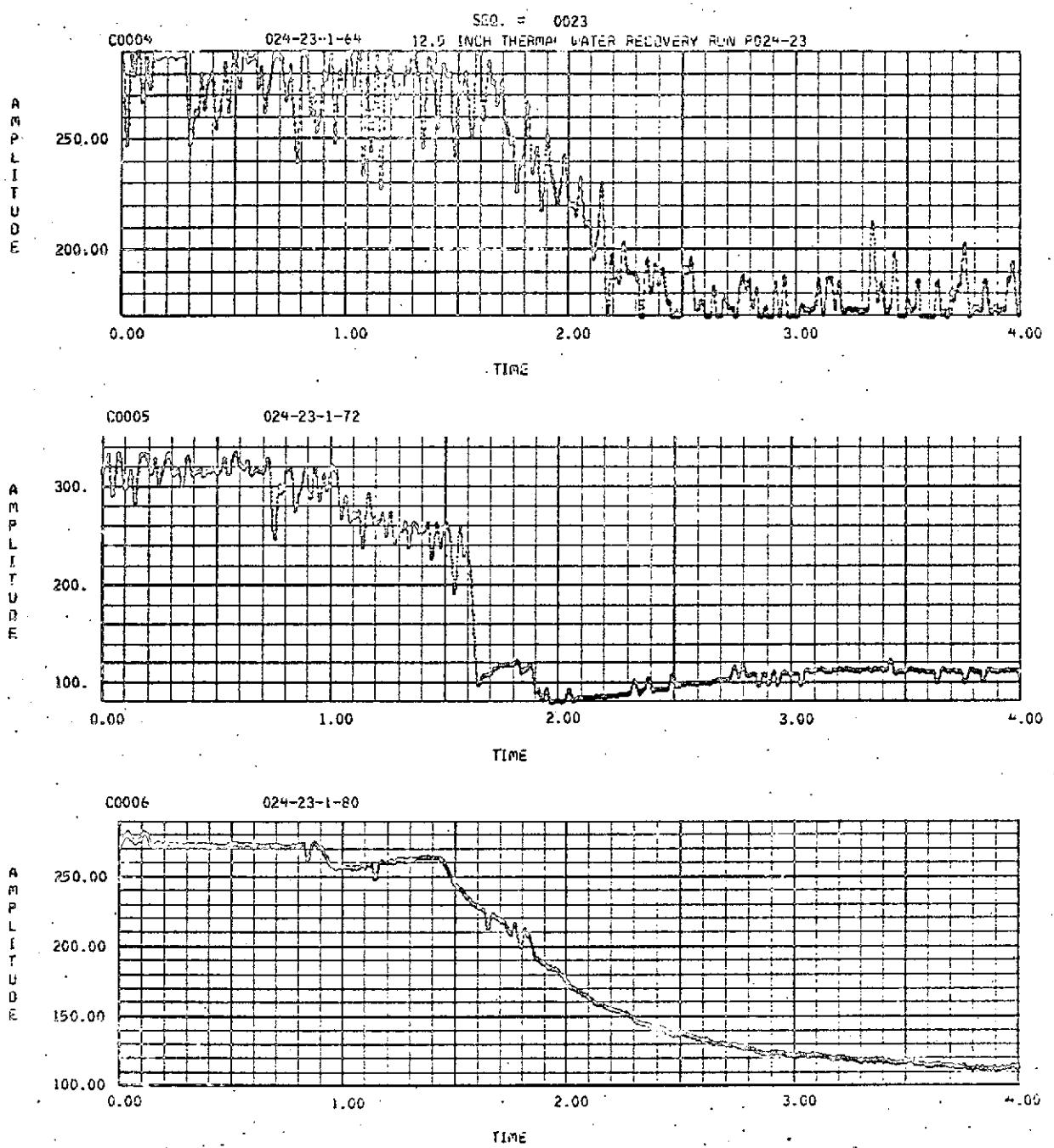
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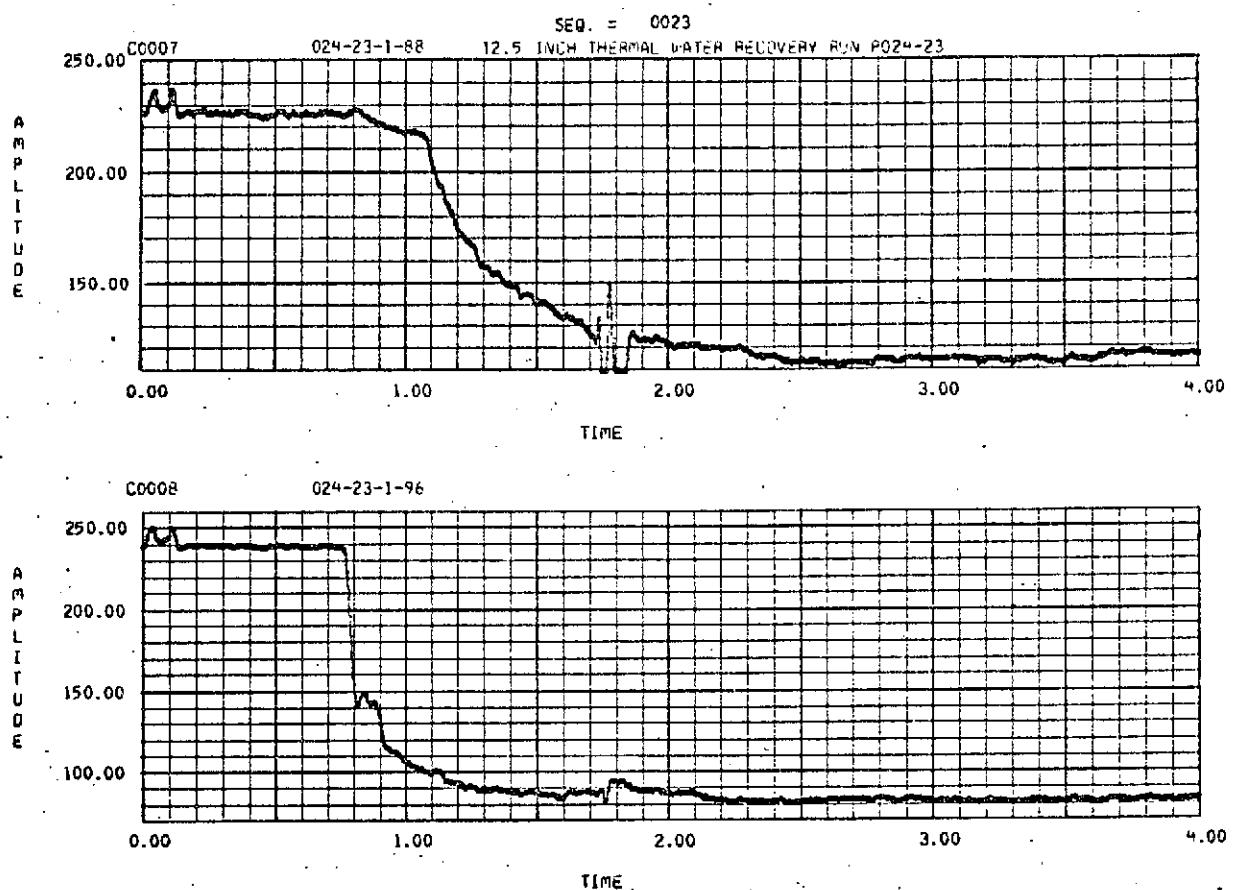


SEQ. # 0023

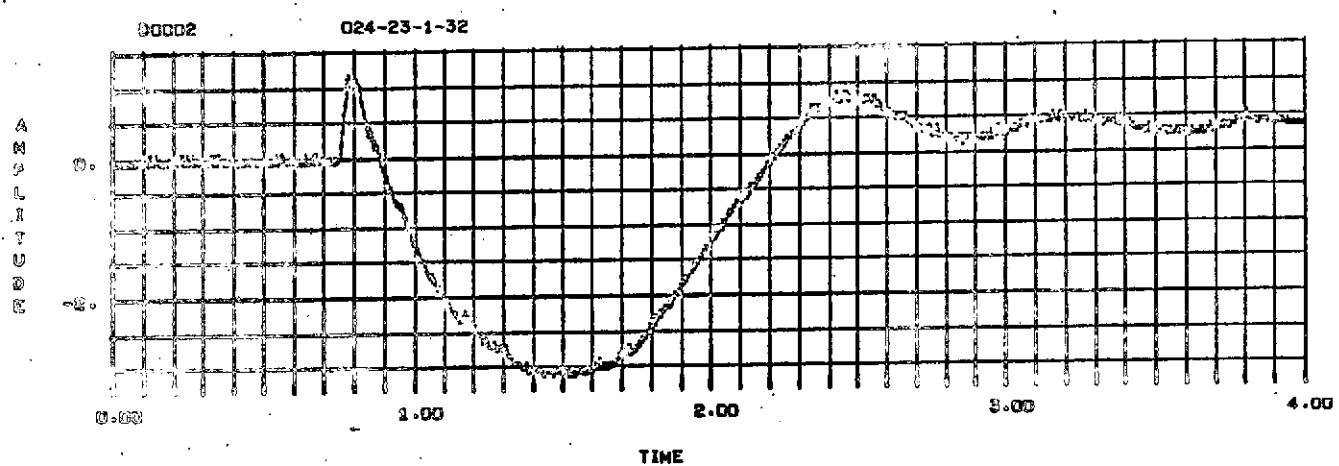
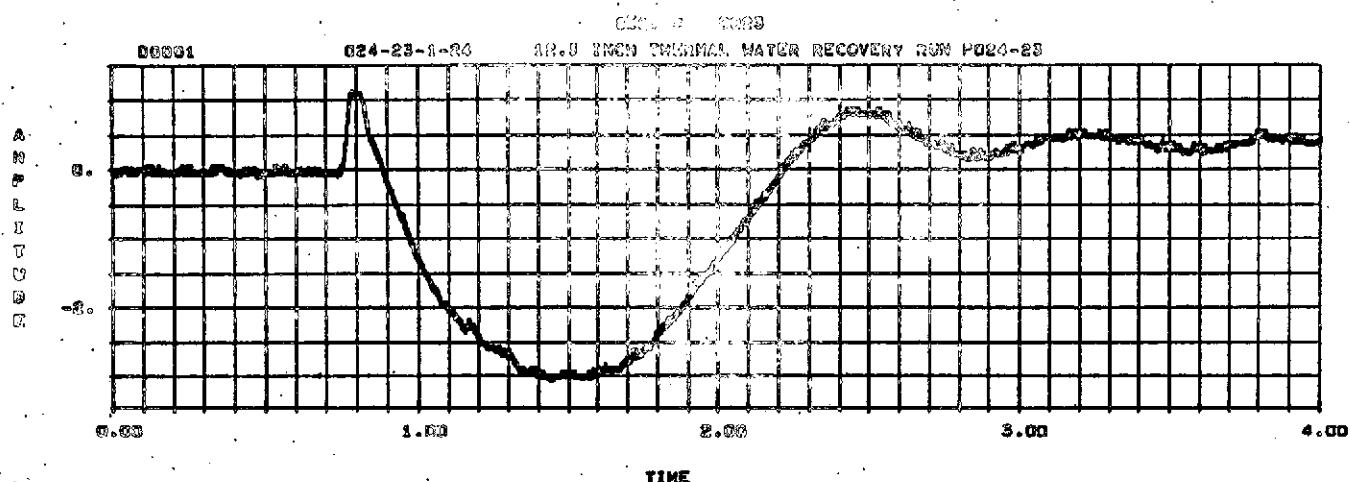


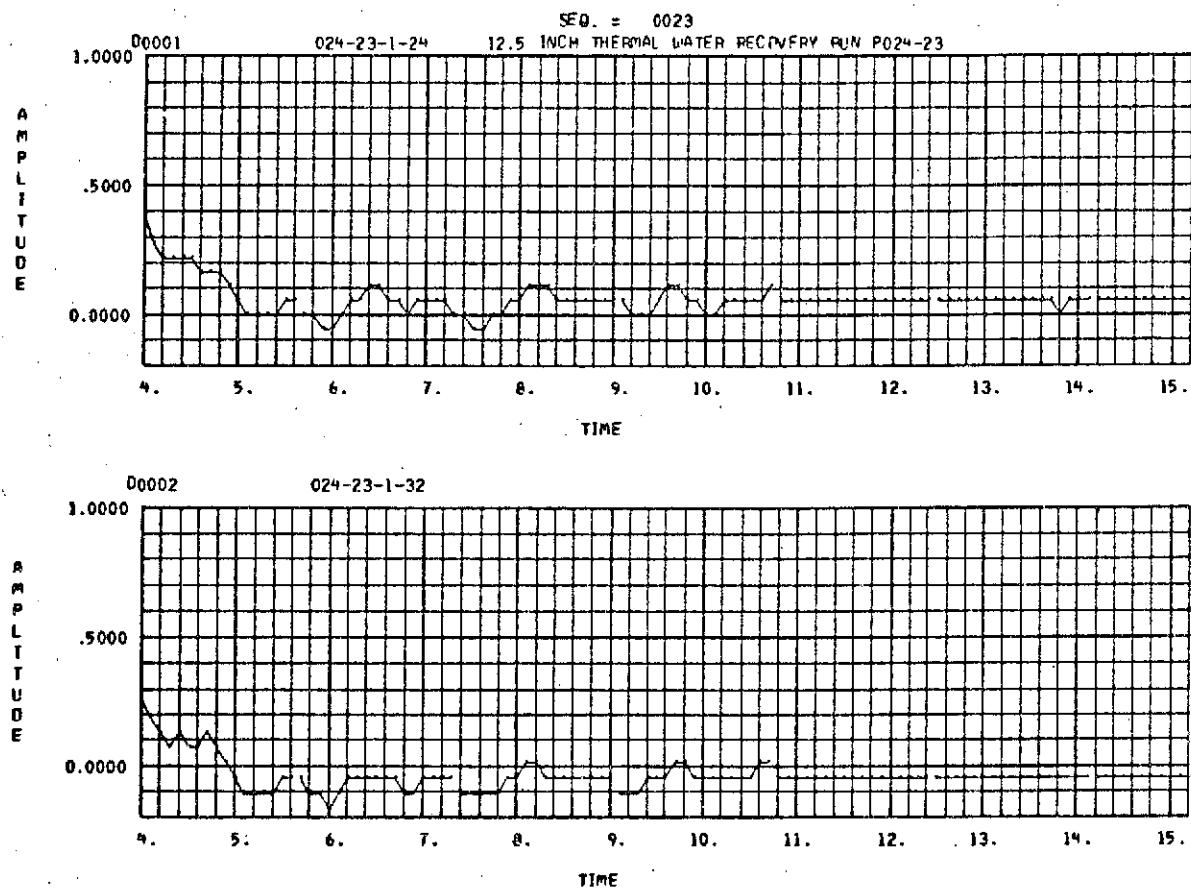




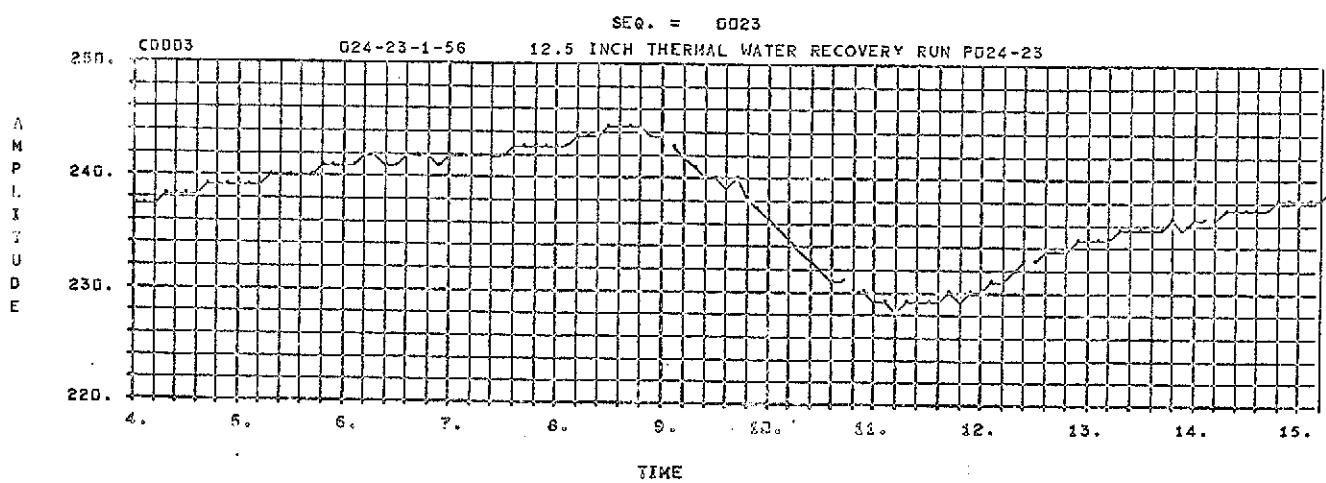
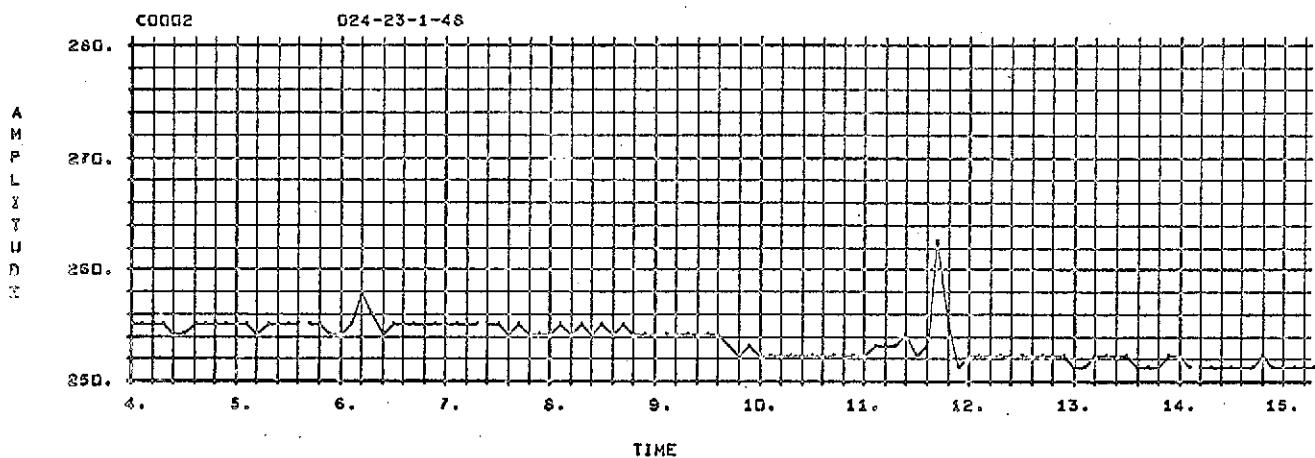
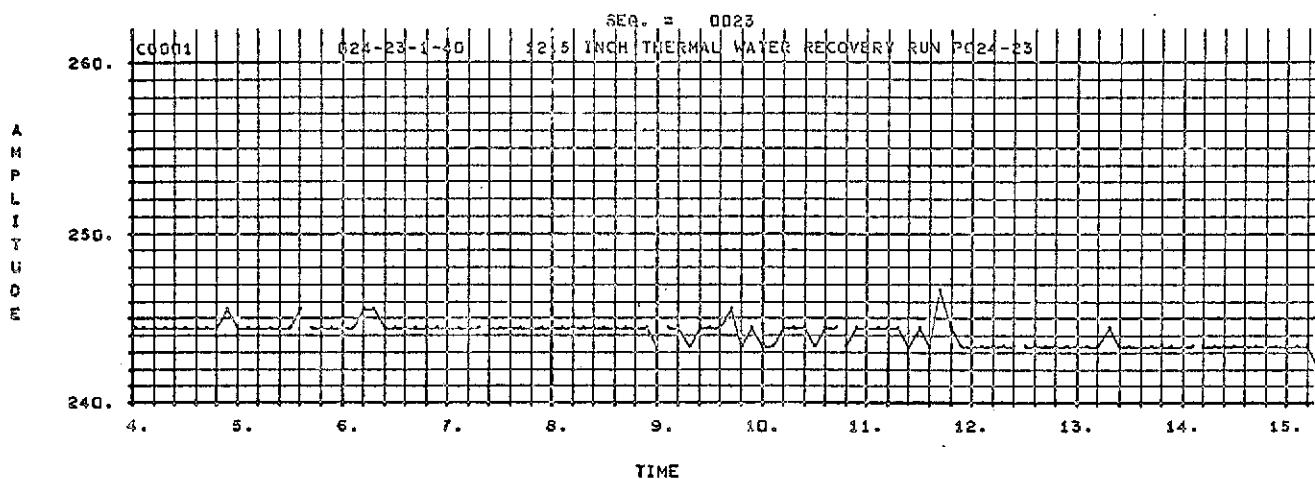


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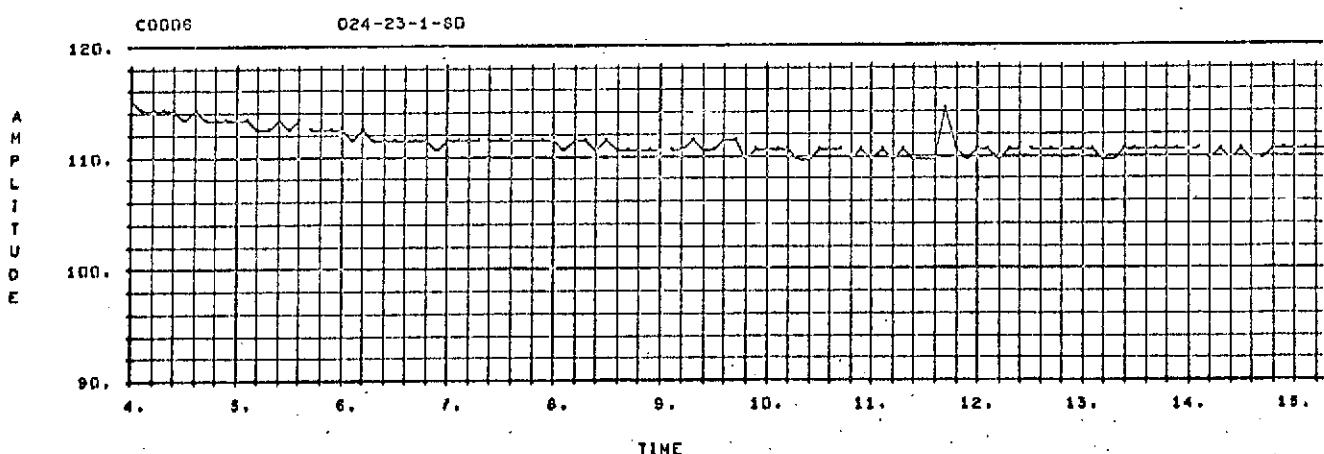
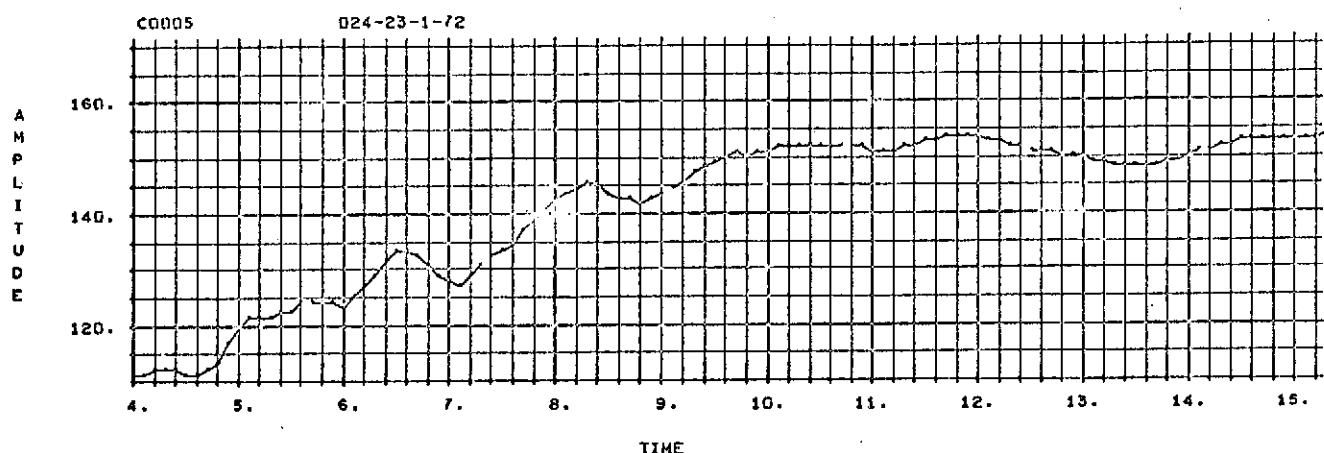
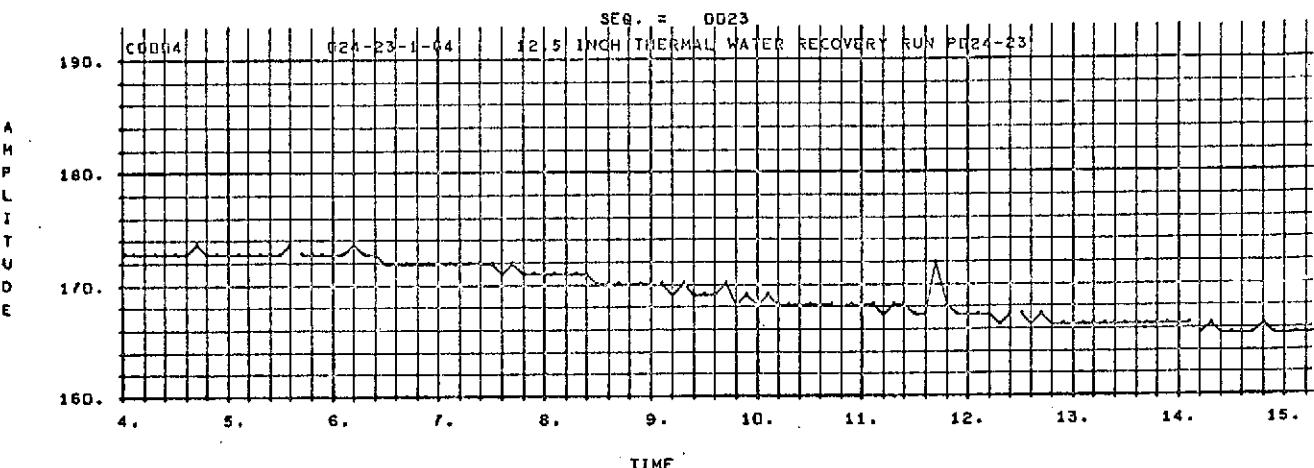




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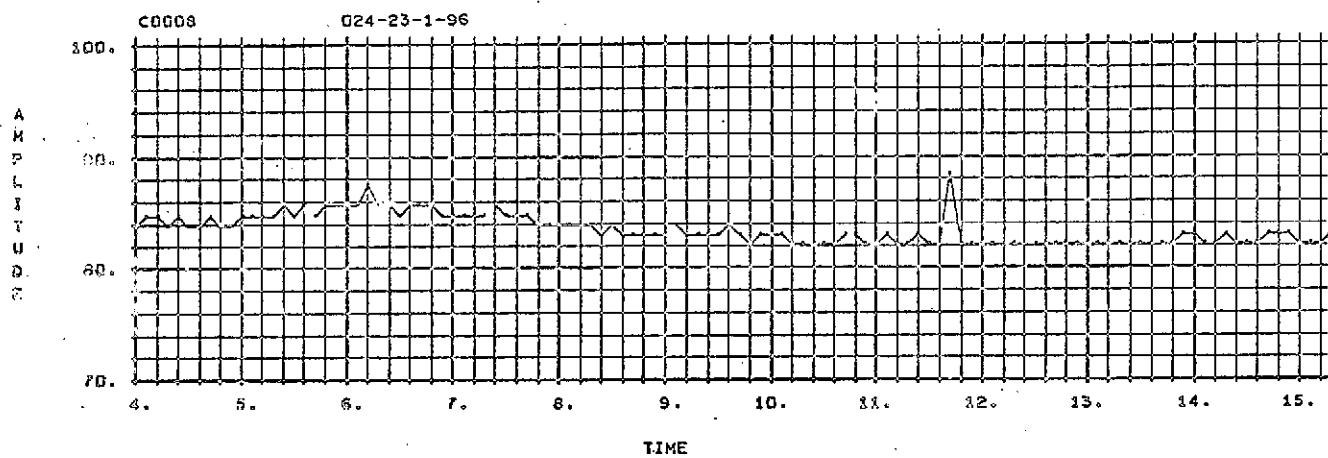
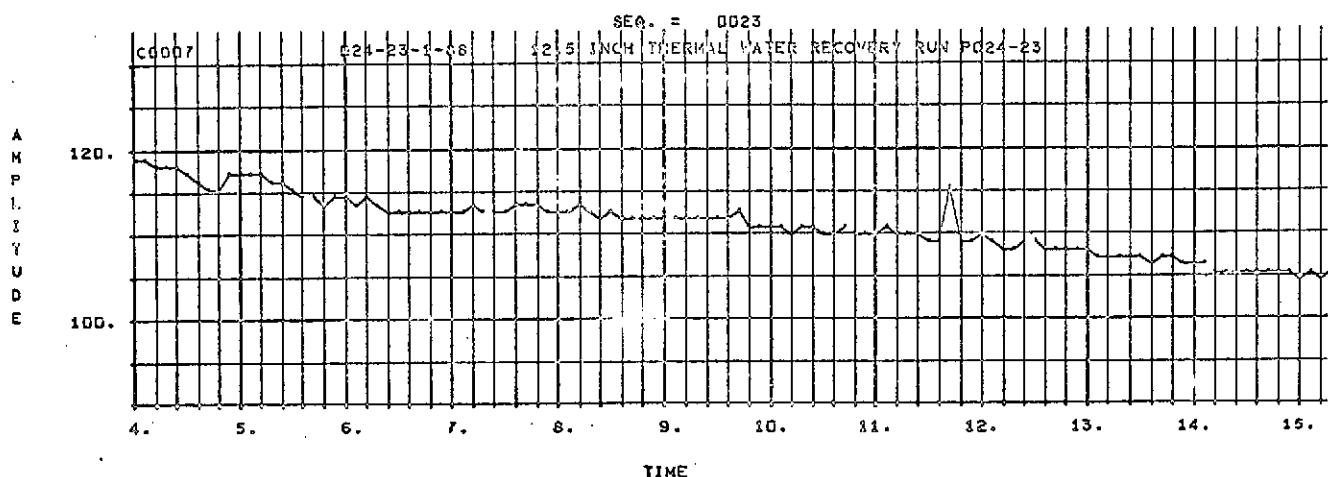


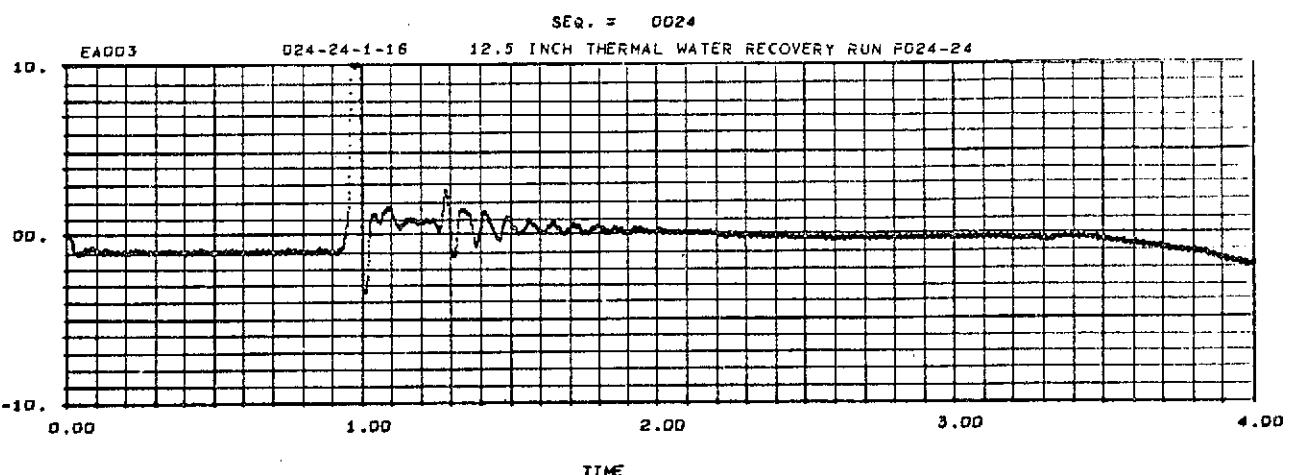
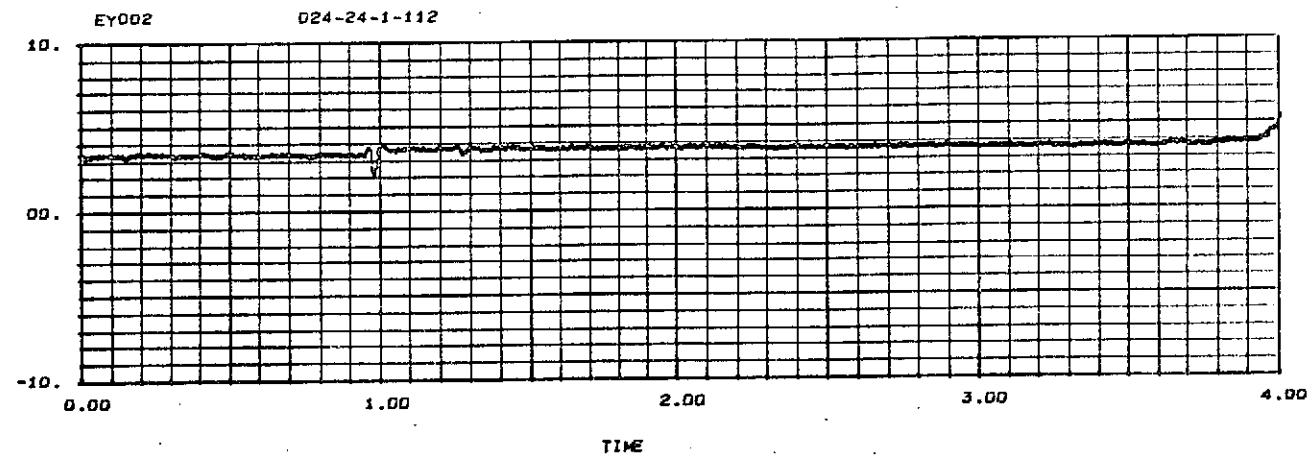
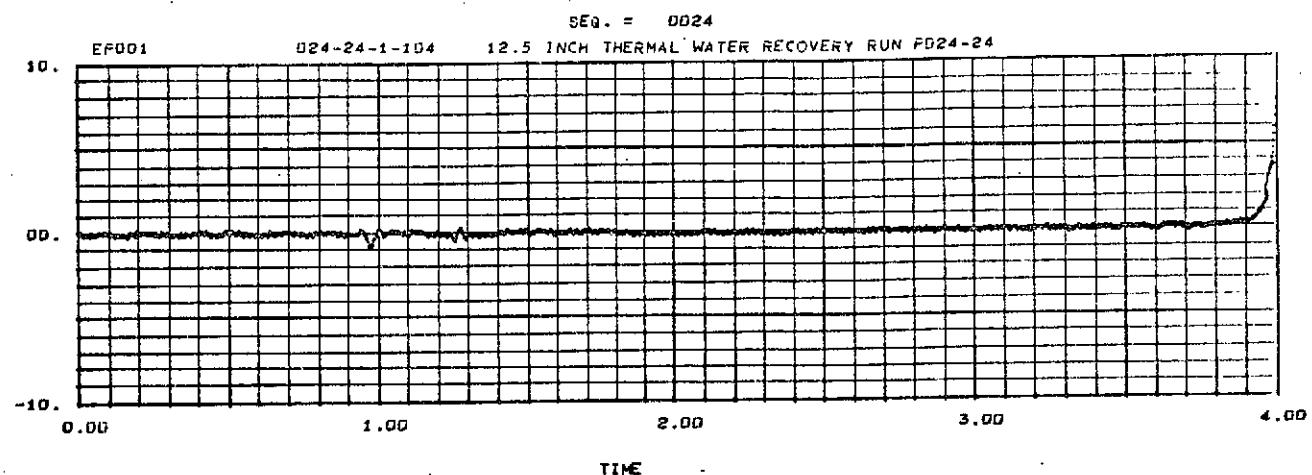
B-192



B-193

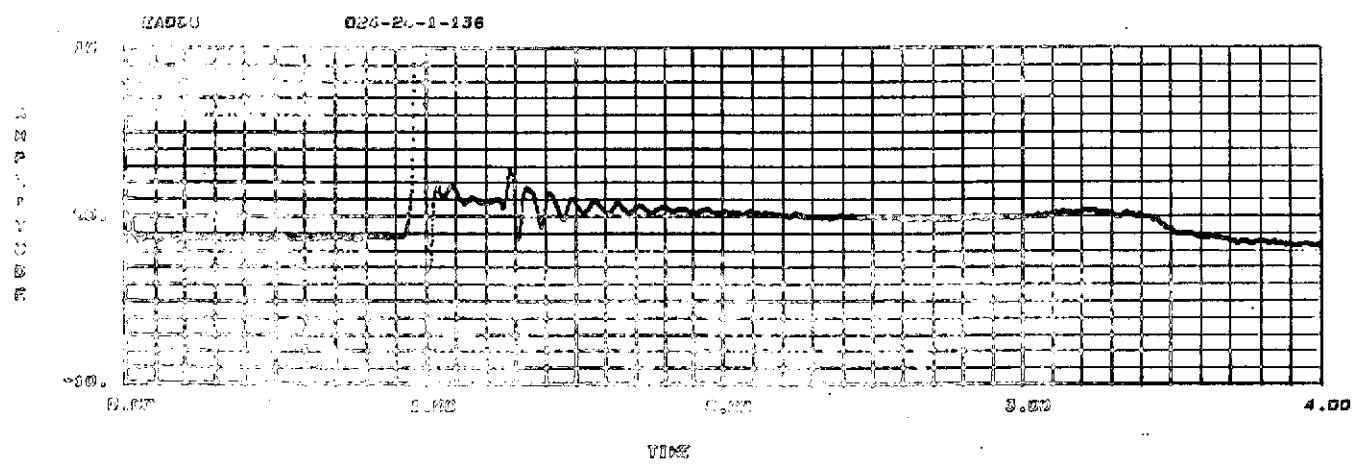
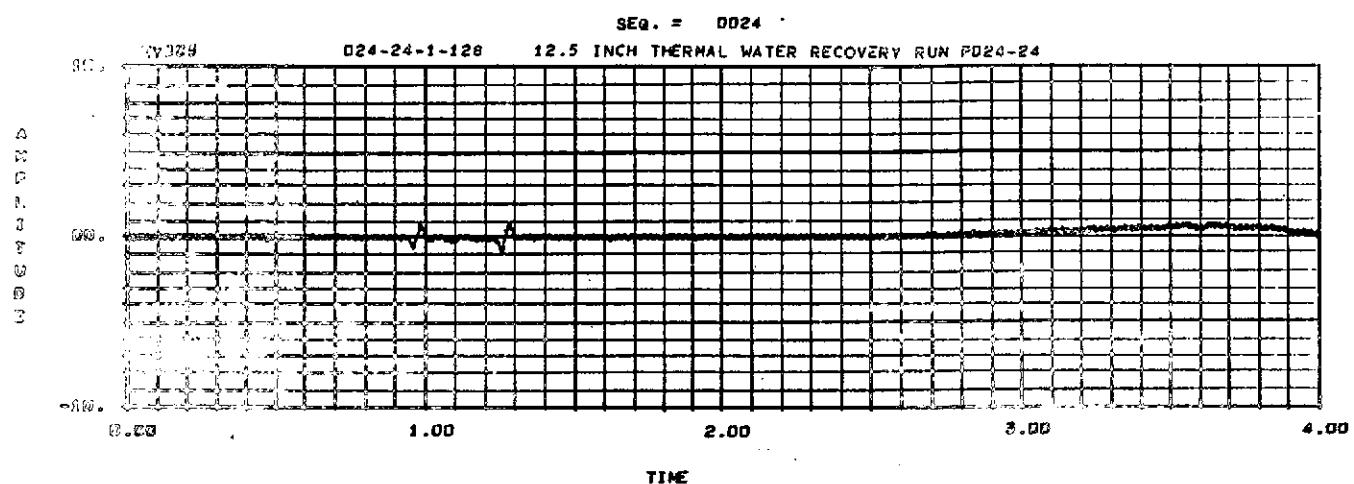
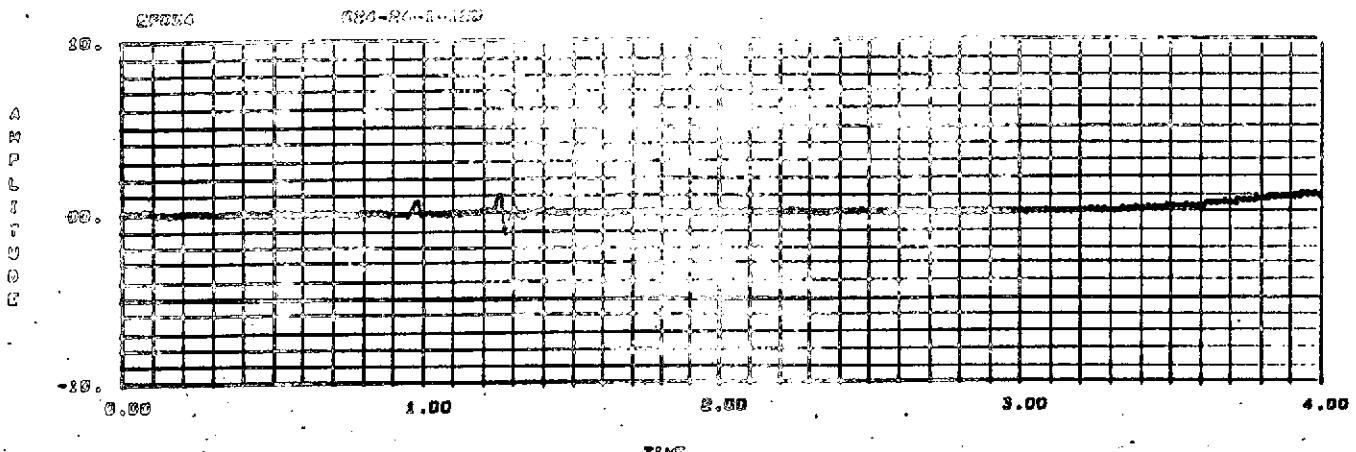
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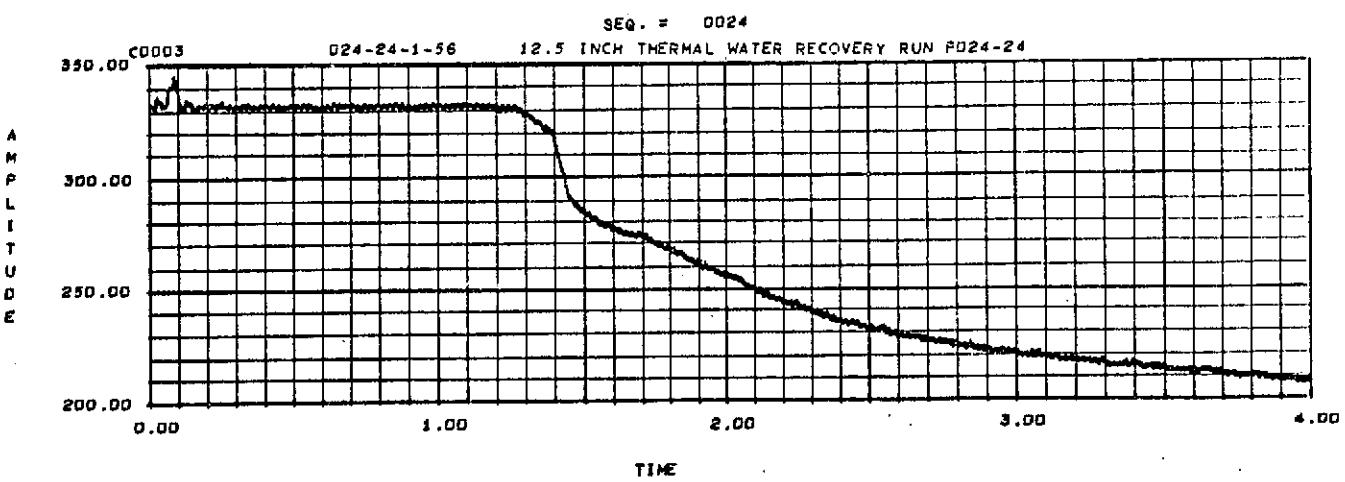
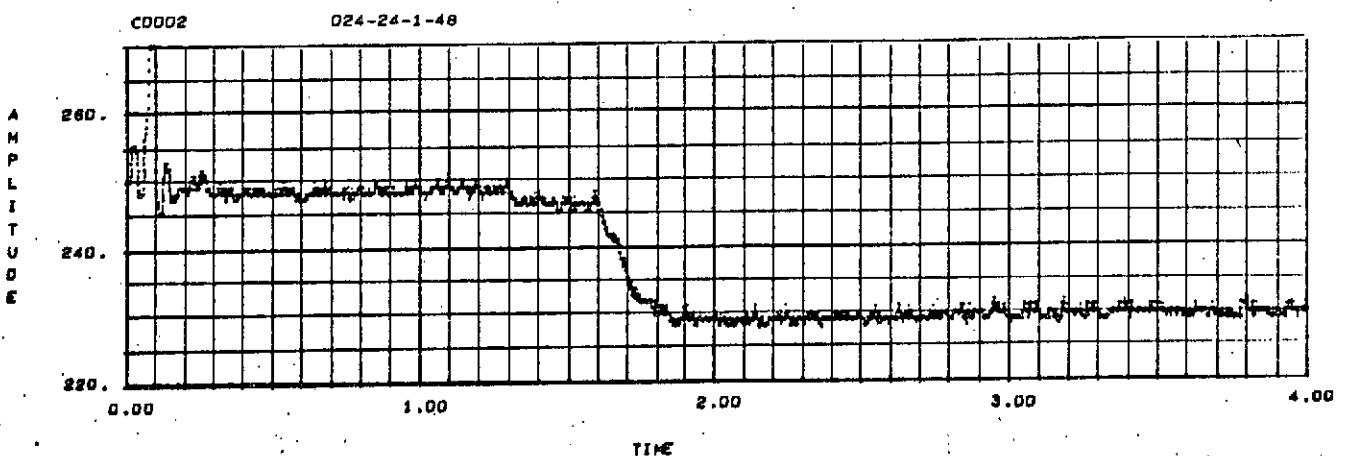
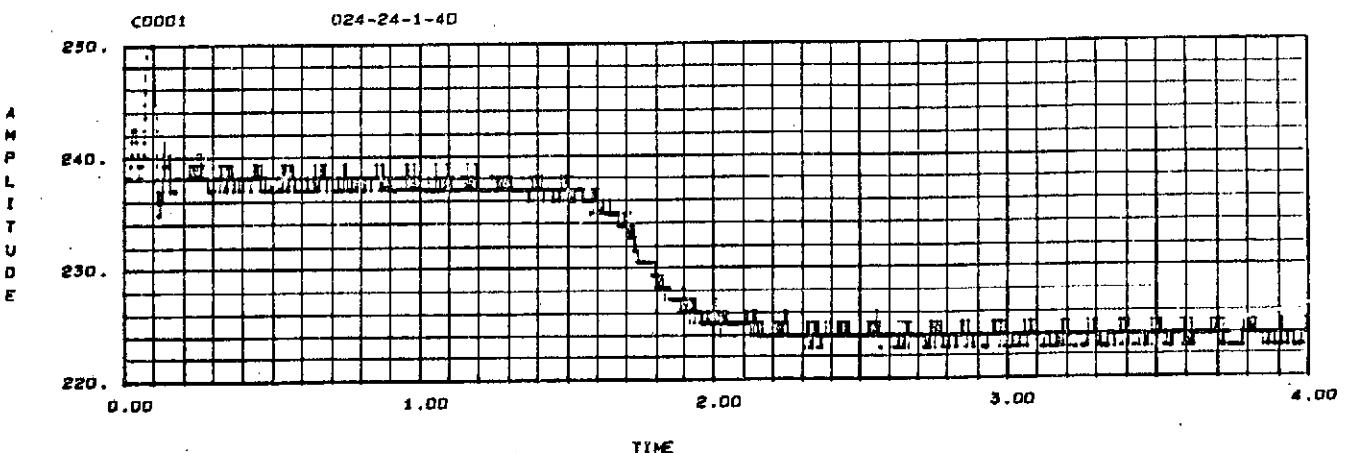




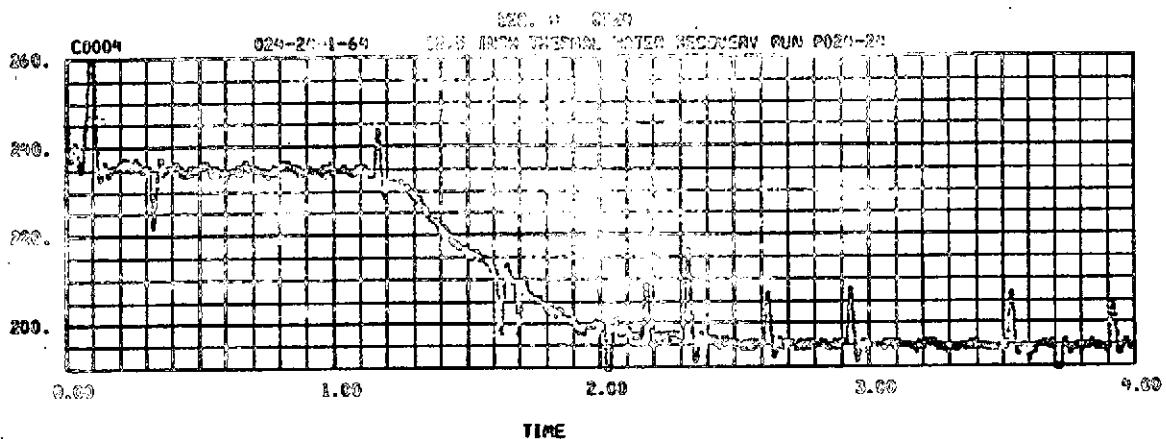
B-195

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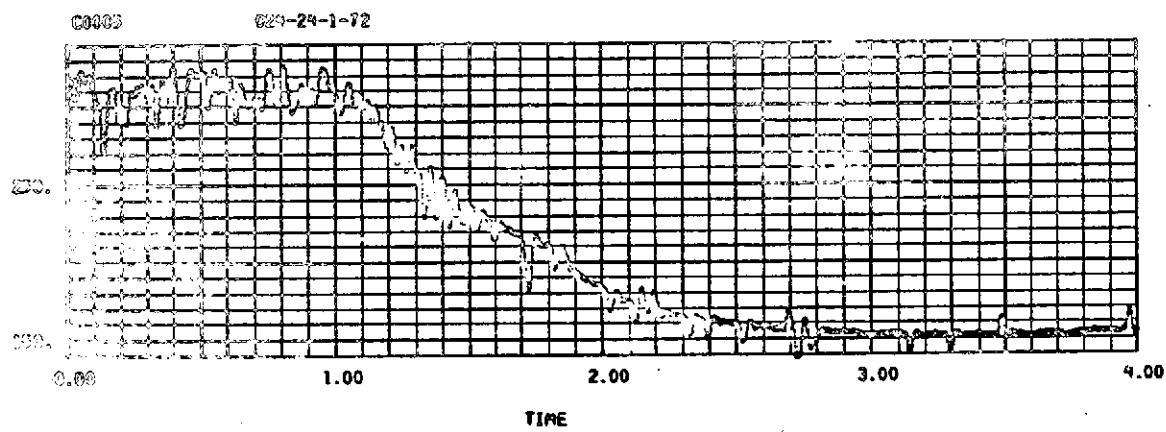




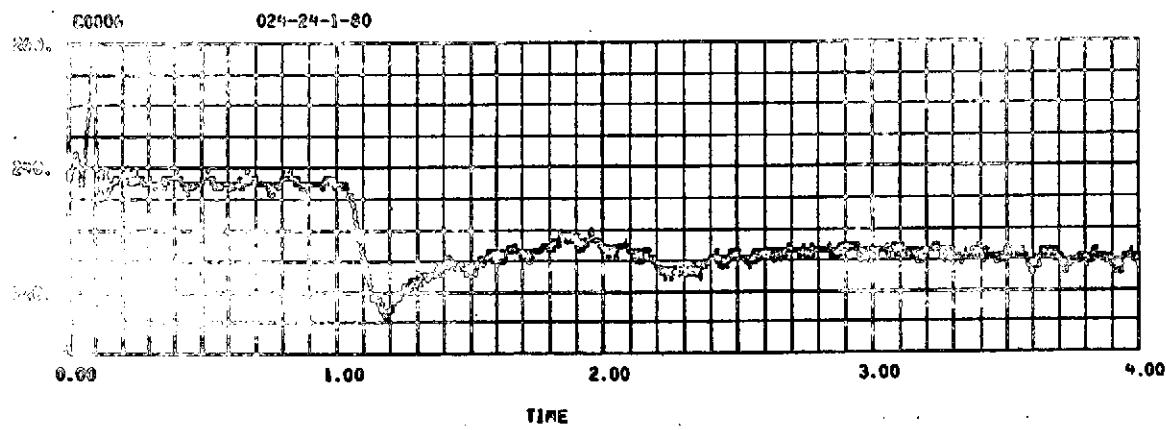
RECOVERY



RECOVERY

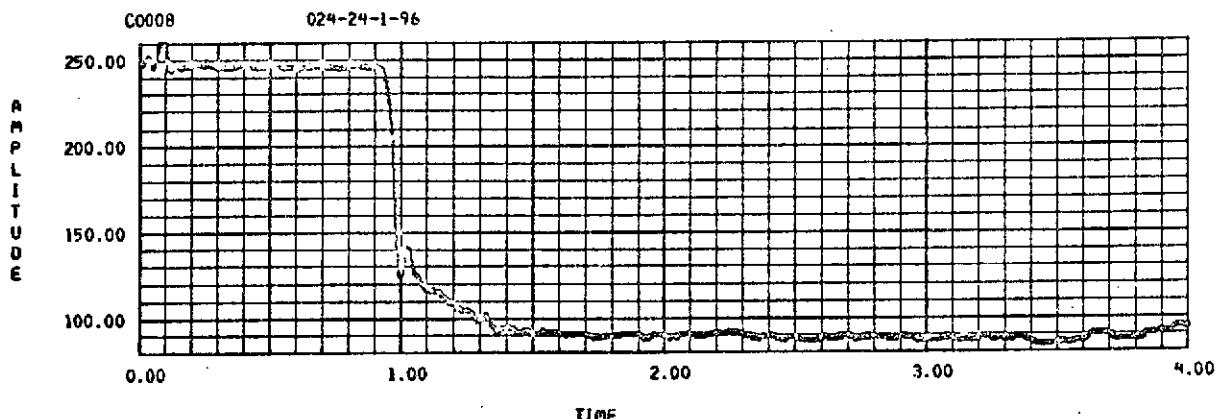
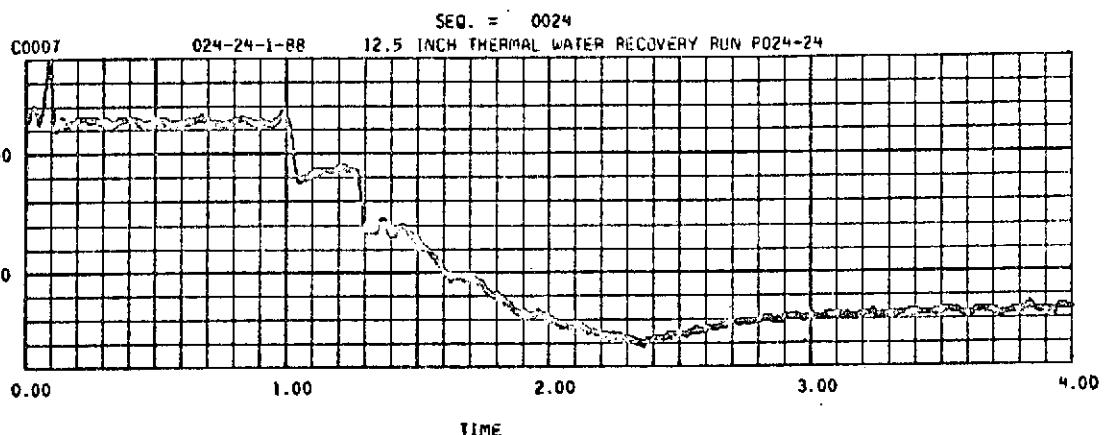


RECOVERY

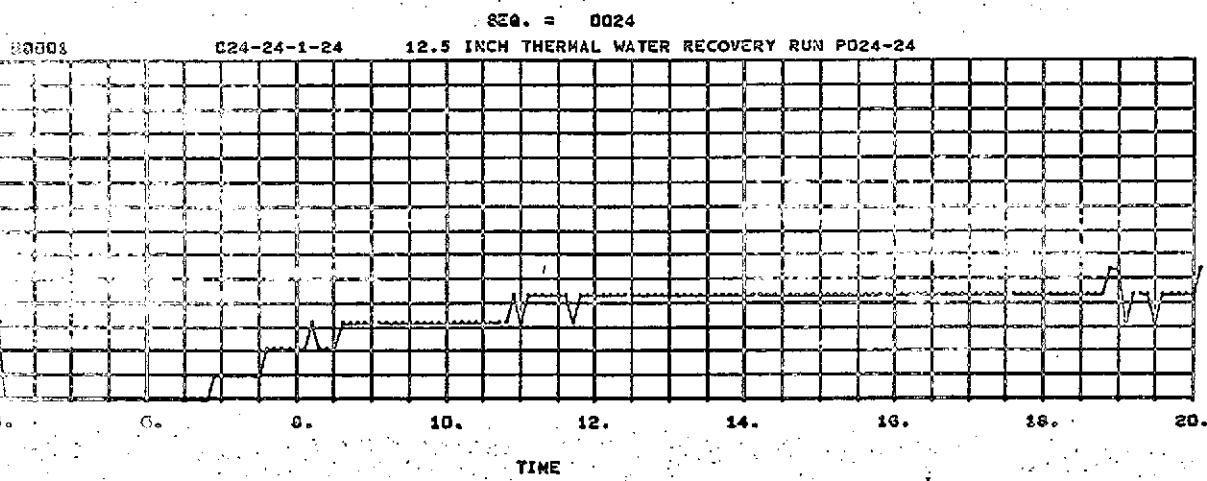
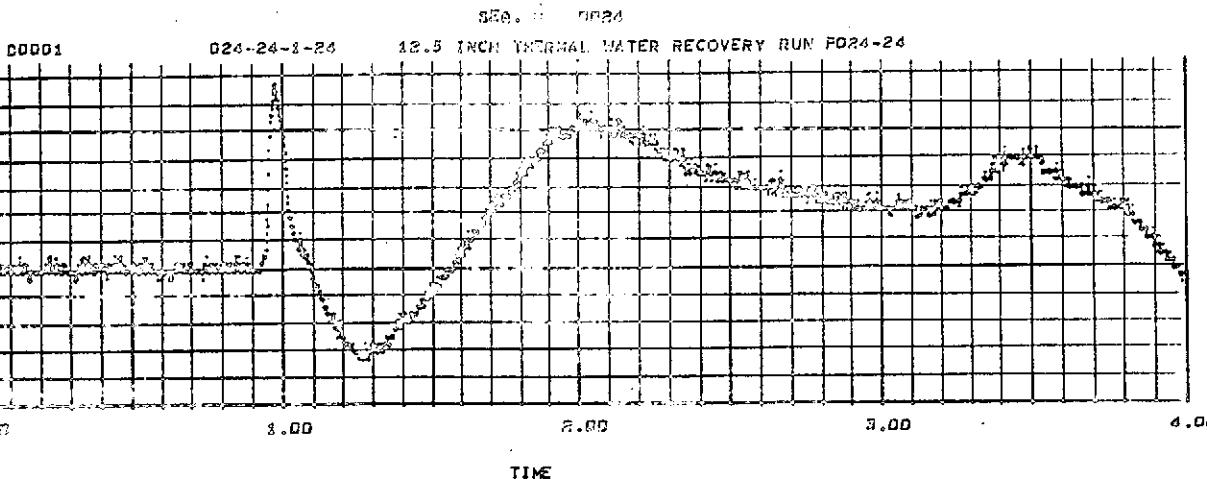


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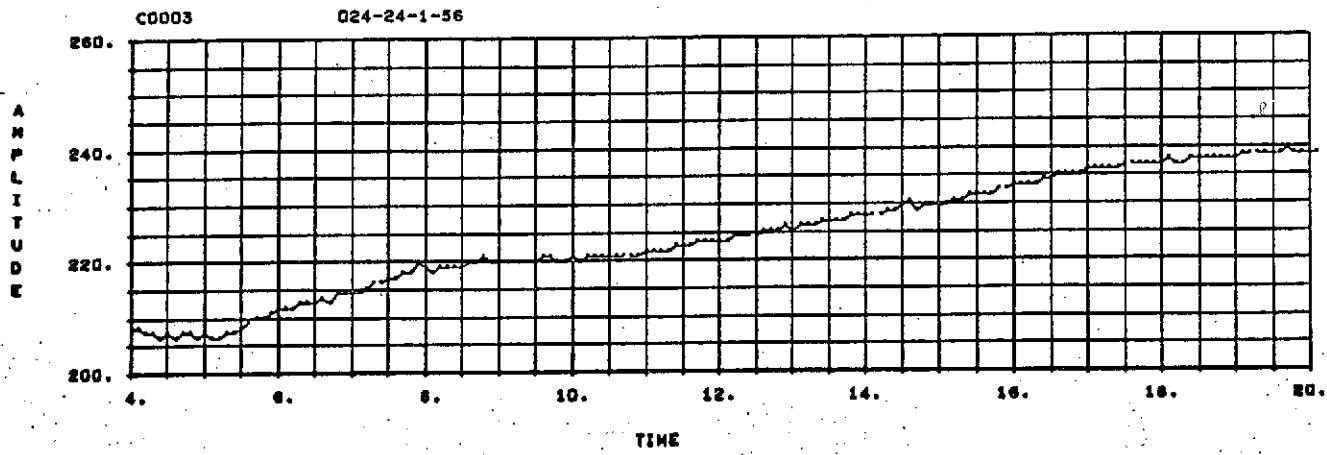
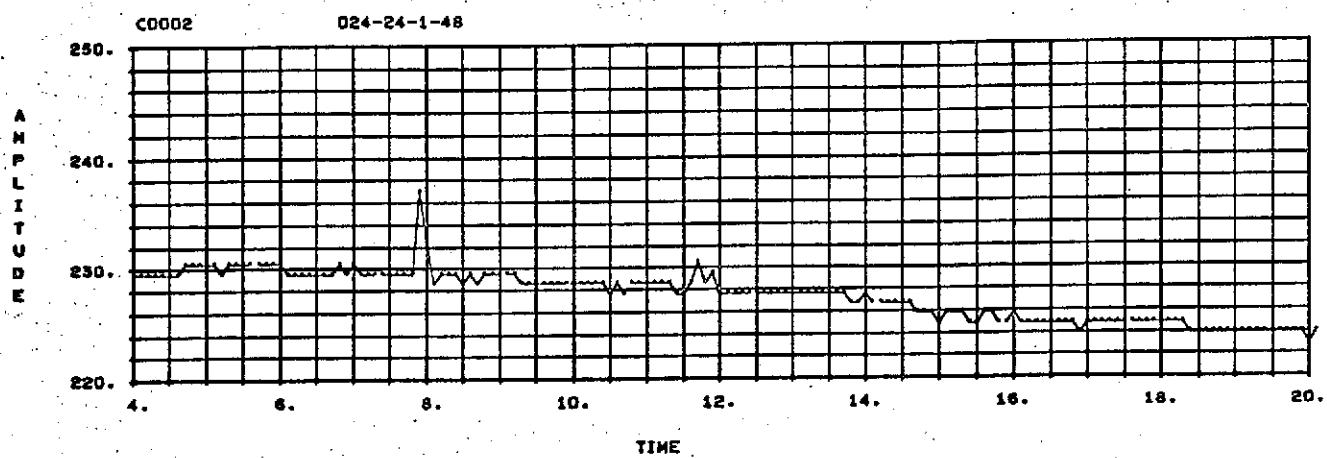
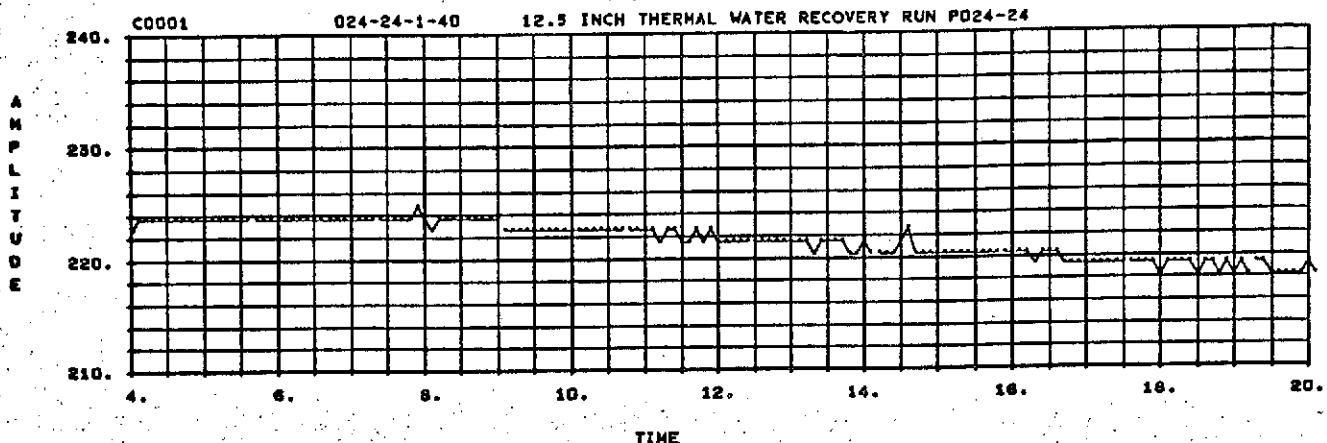


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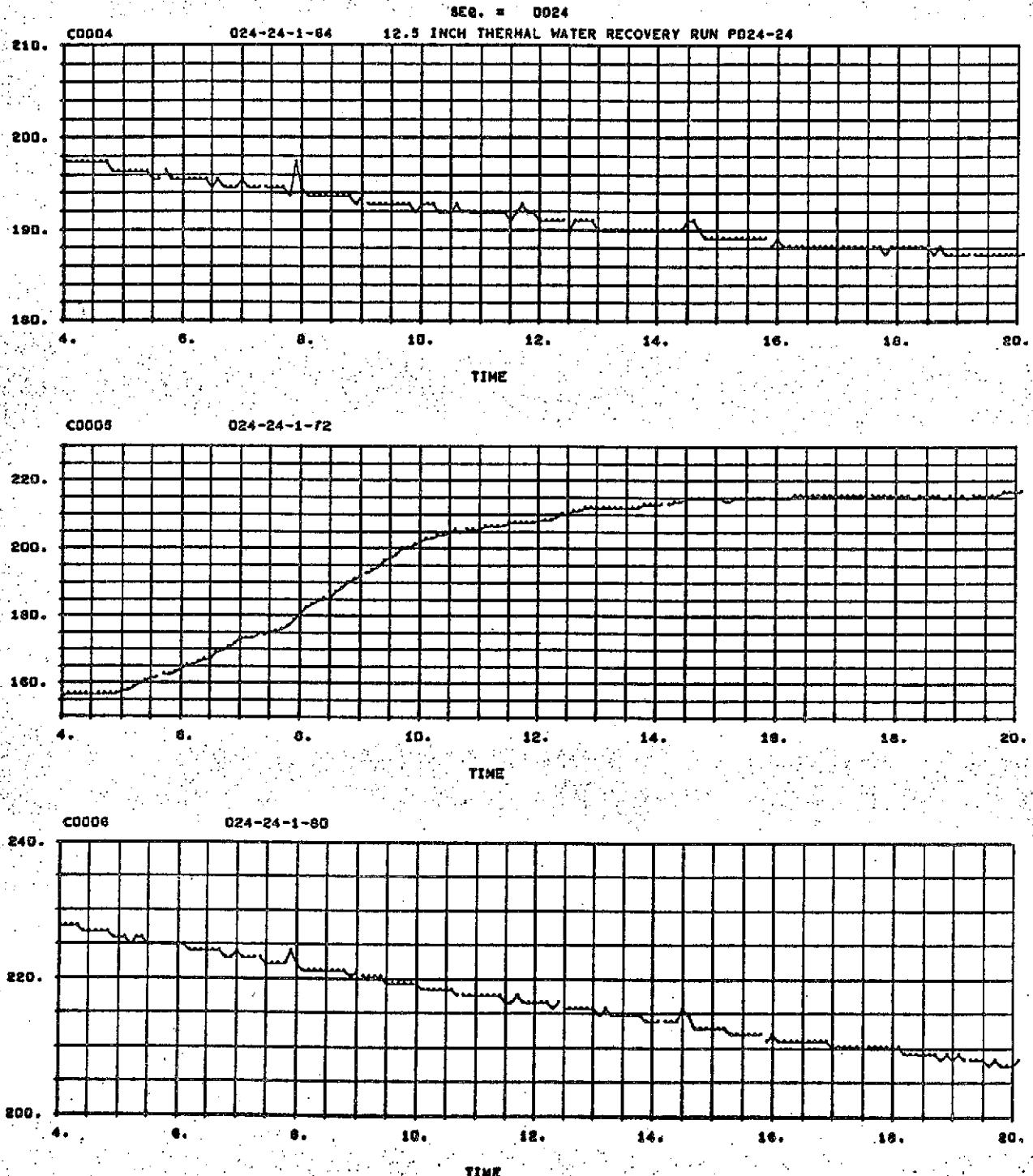


SEQ. 3 0024

024-24-1-40 12.5 INCH THERMAL WATER RECOVERY RUN P024-24

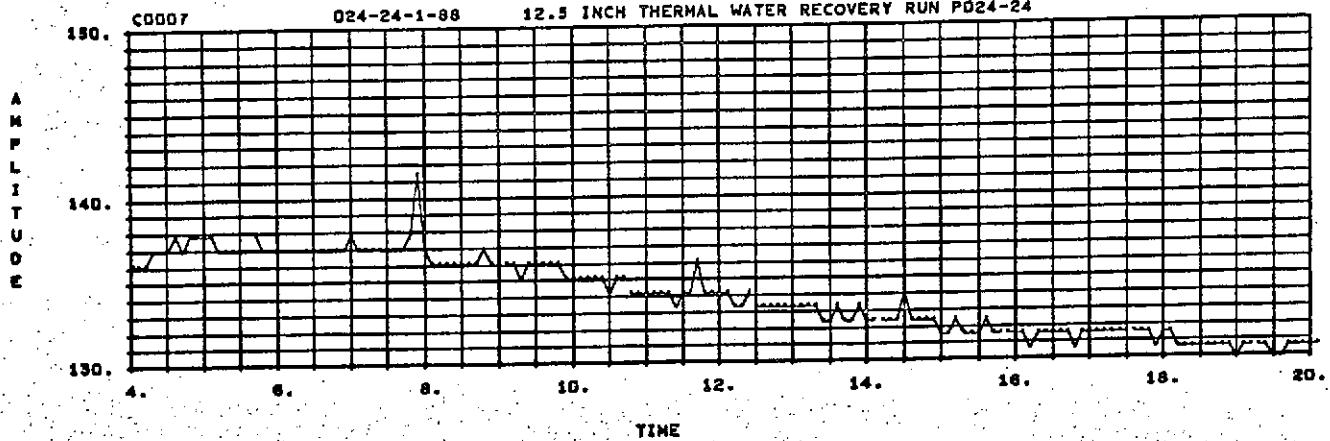


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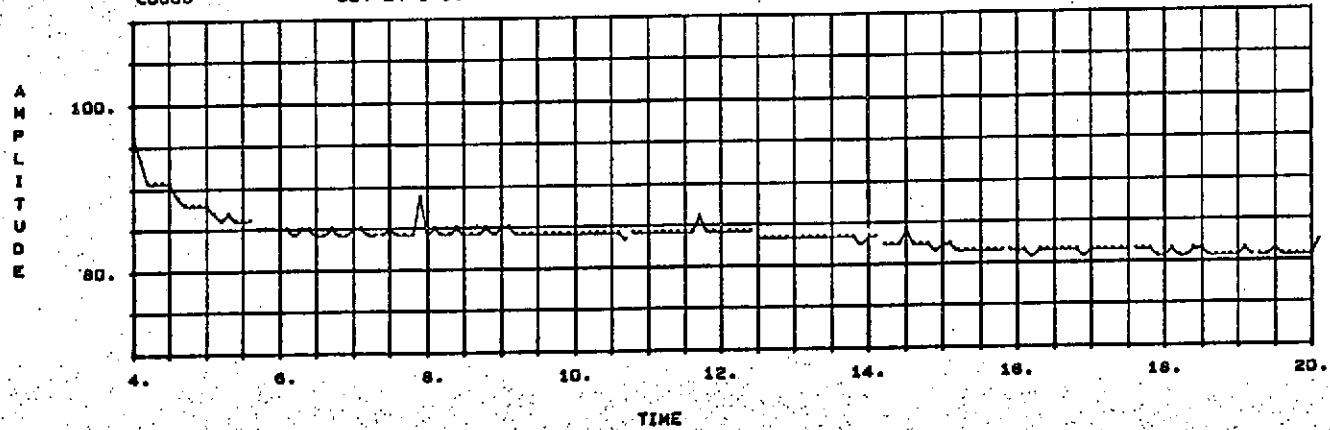


SEQ. # 0024

024-24-1-88 12.5 INCH THERMAL WATER RECOVERY RUN PD24-24



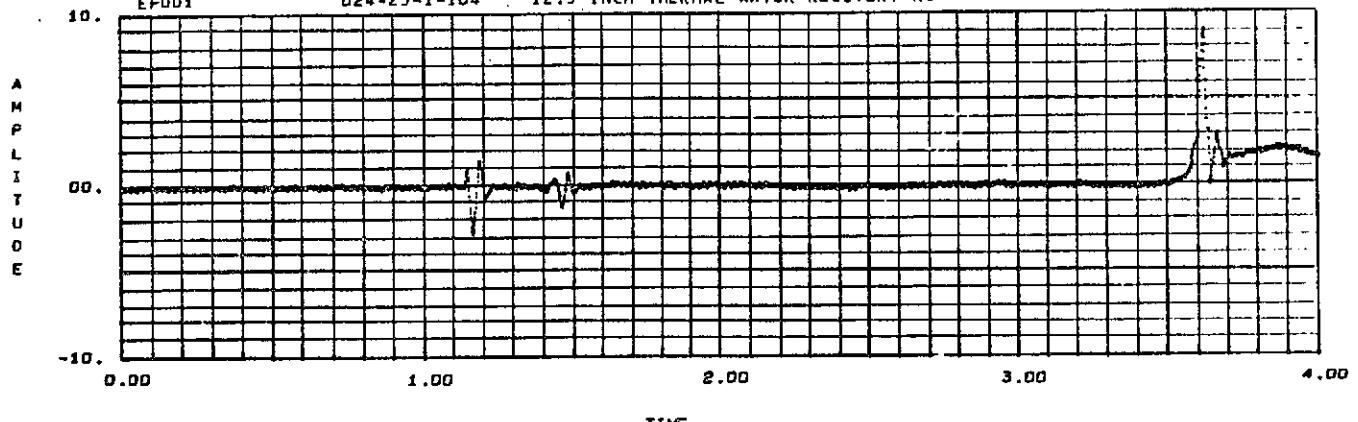
C0008 024-24-1-96



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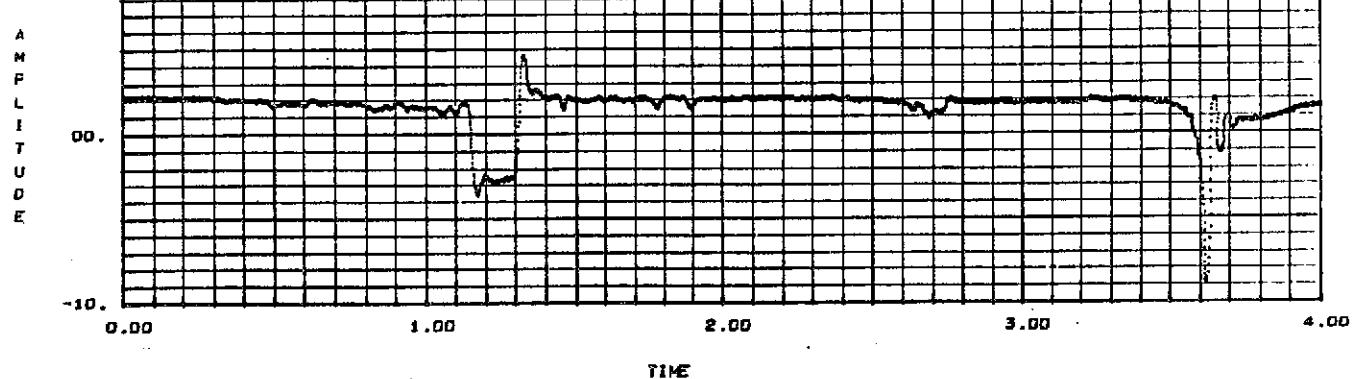
SEQ. = 0025

EF001 D24-25-1-104 12.5 INCH THERMAL WATER RECOVERY RUN P024-25



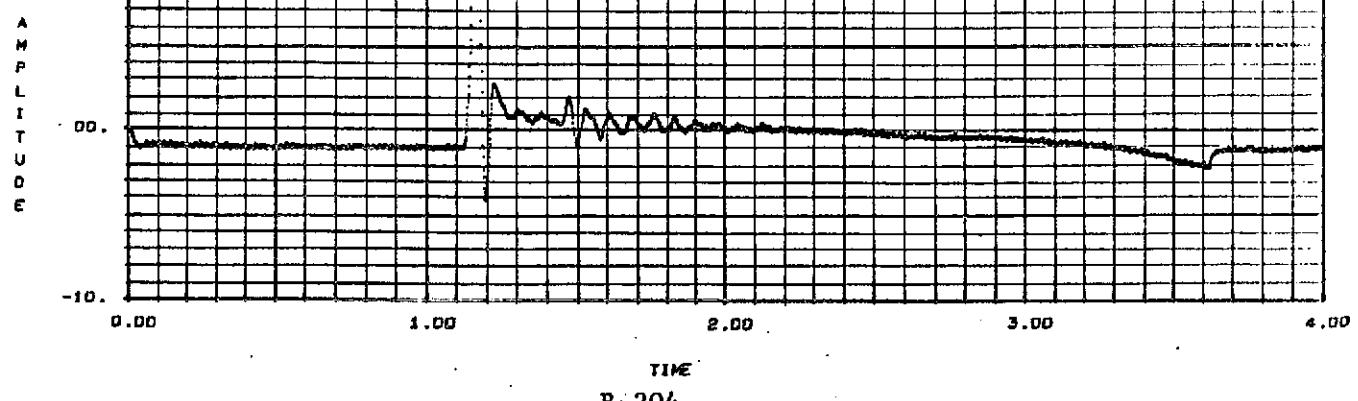
EY002

D24-25-1-112

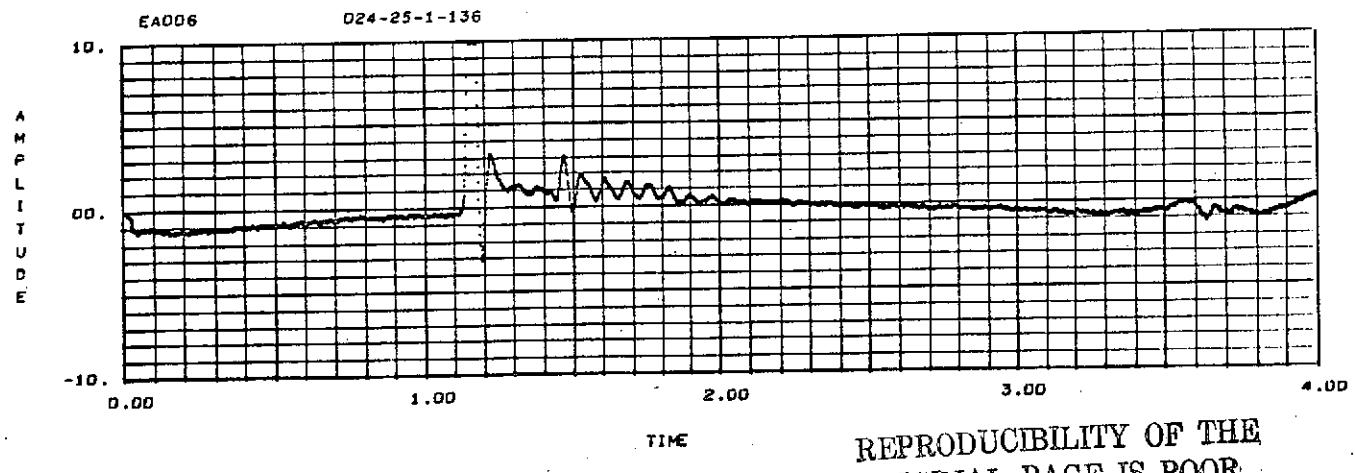
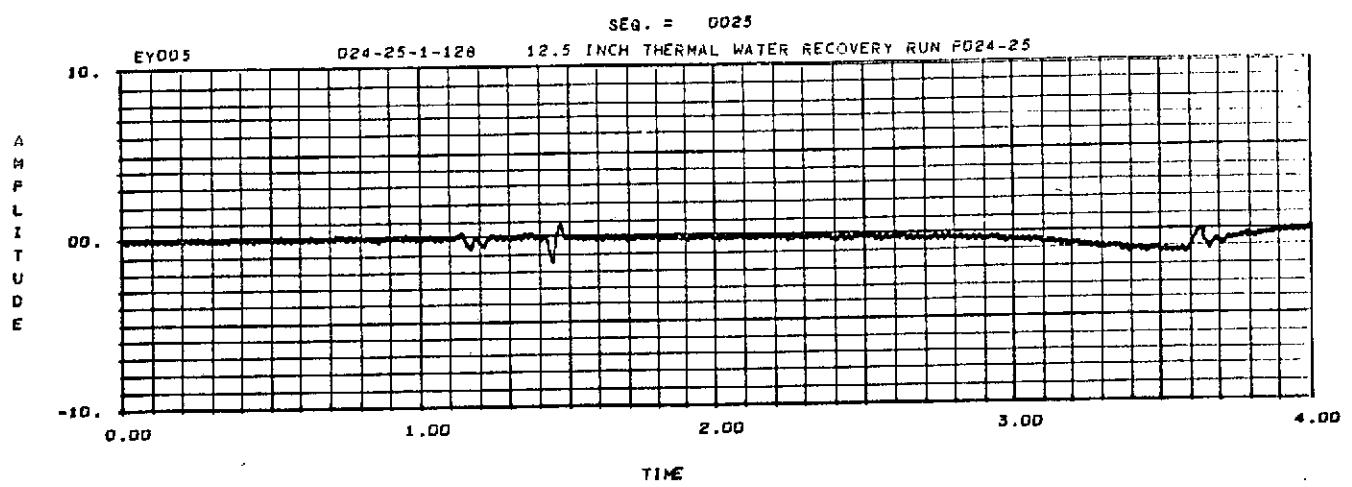
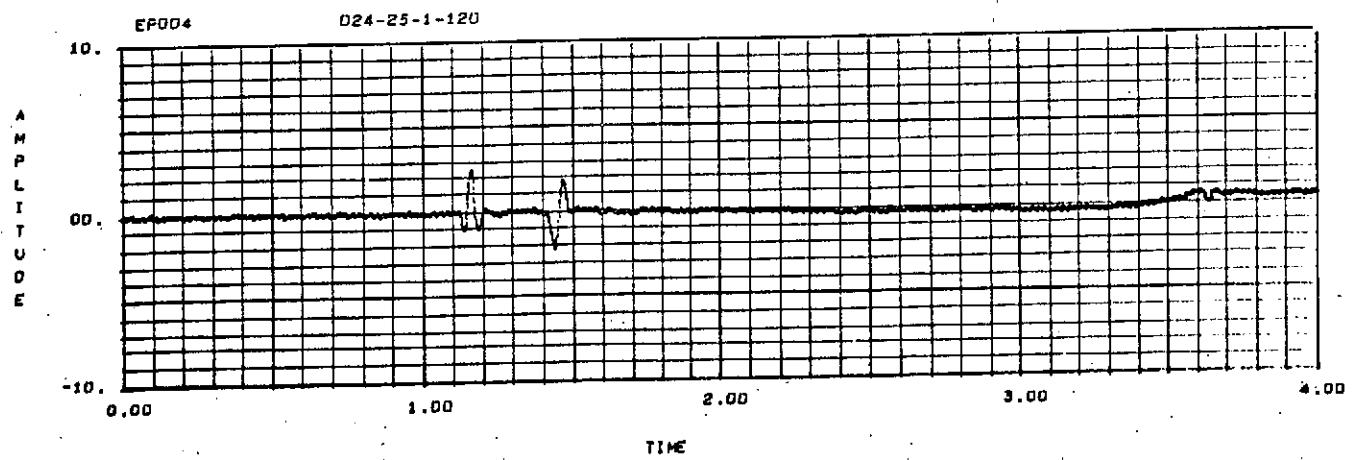


SEQ. = 0025

EA003 D24-25-1-16 12.5 INCH THERMAL WATER RECOVERY RUN P024-25

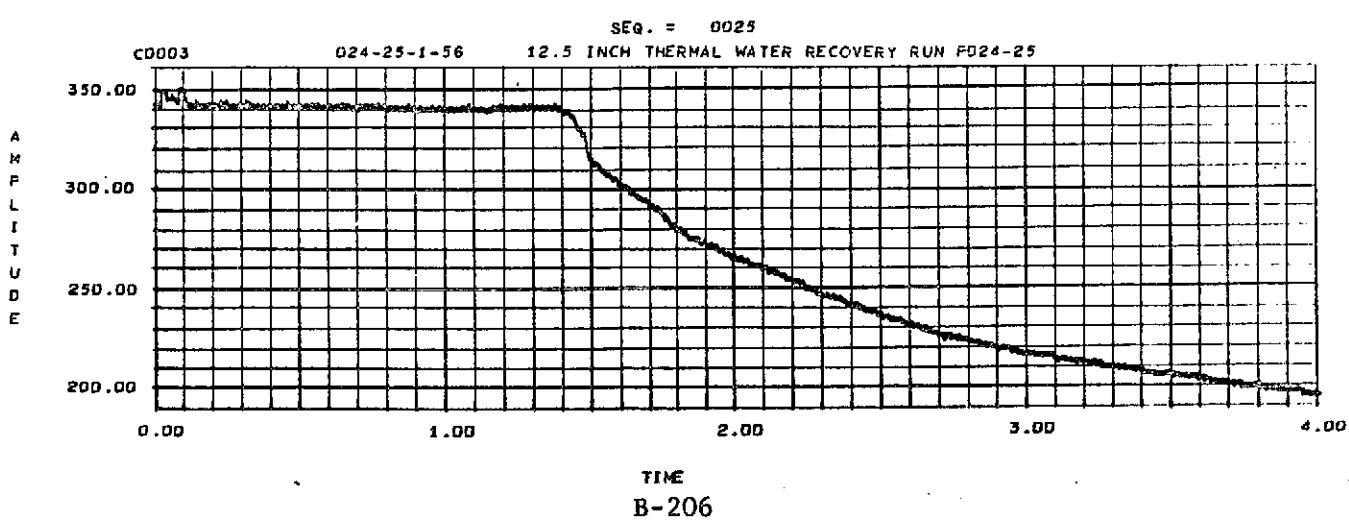
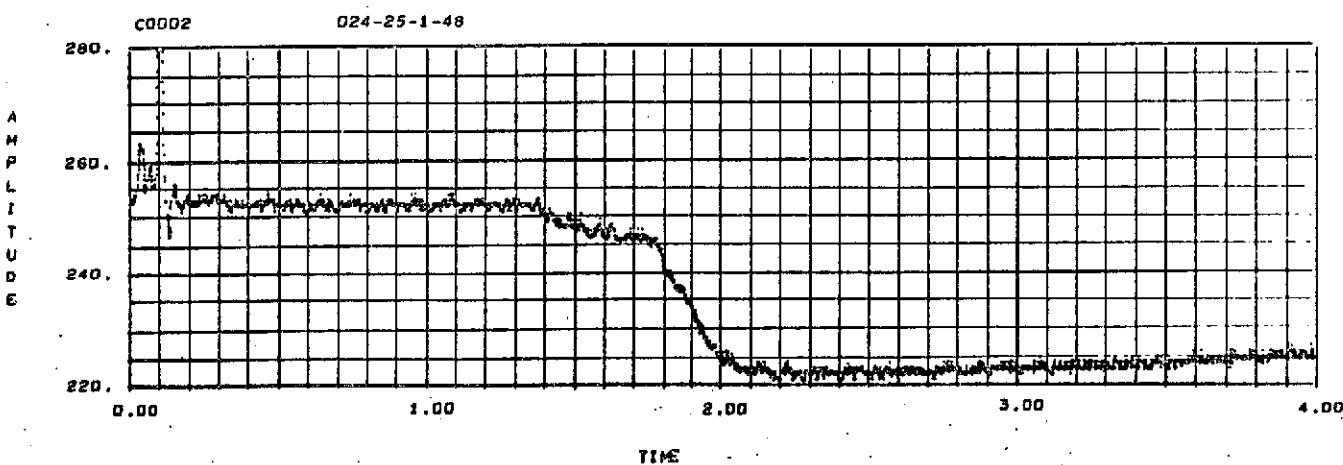
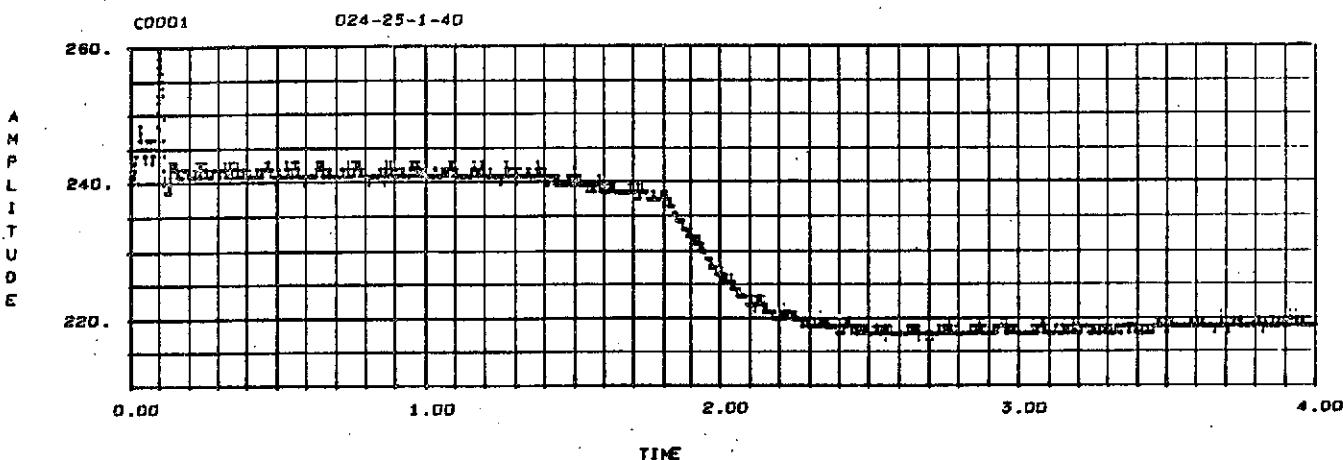


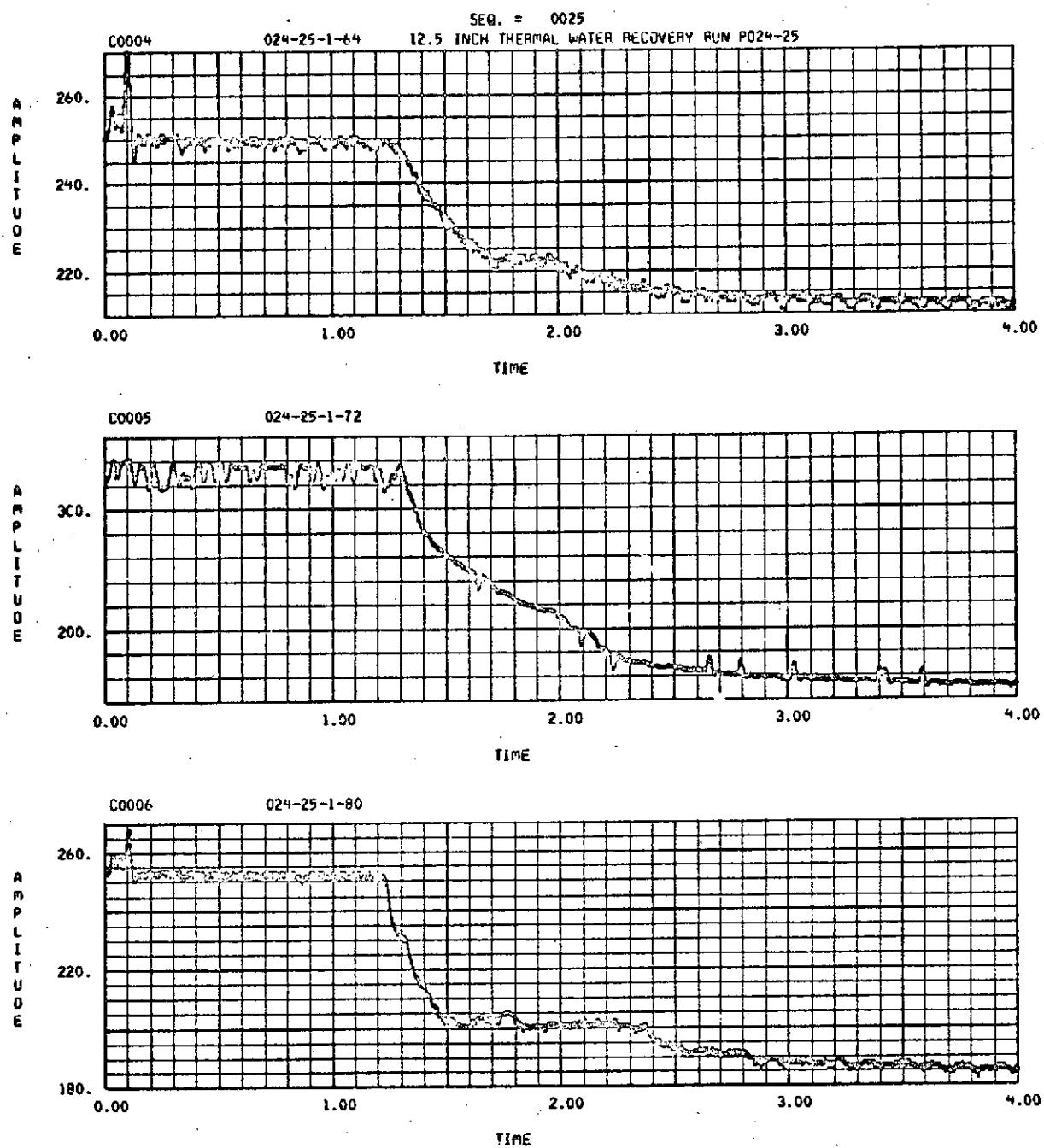
B-204



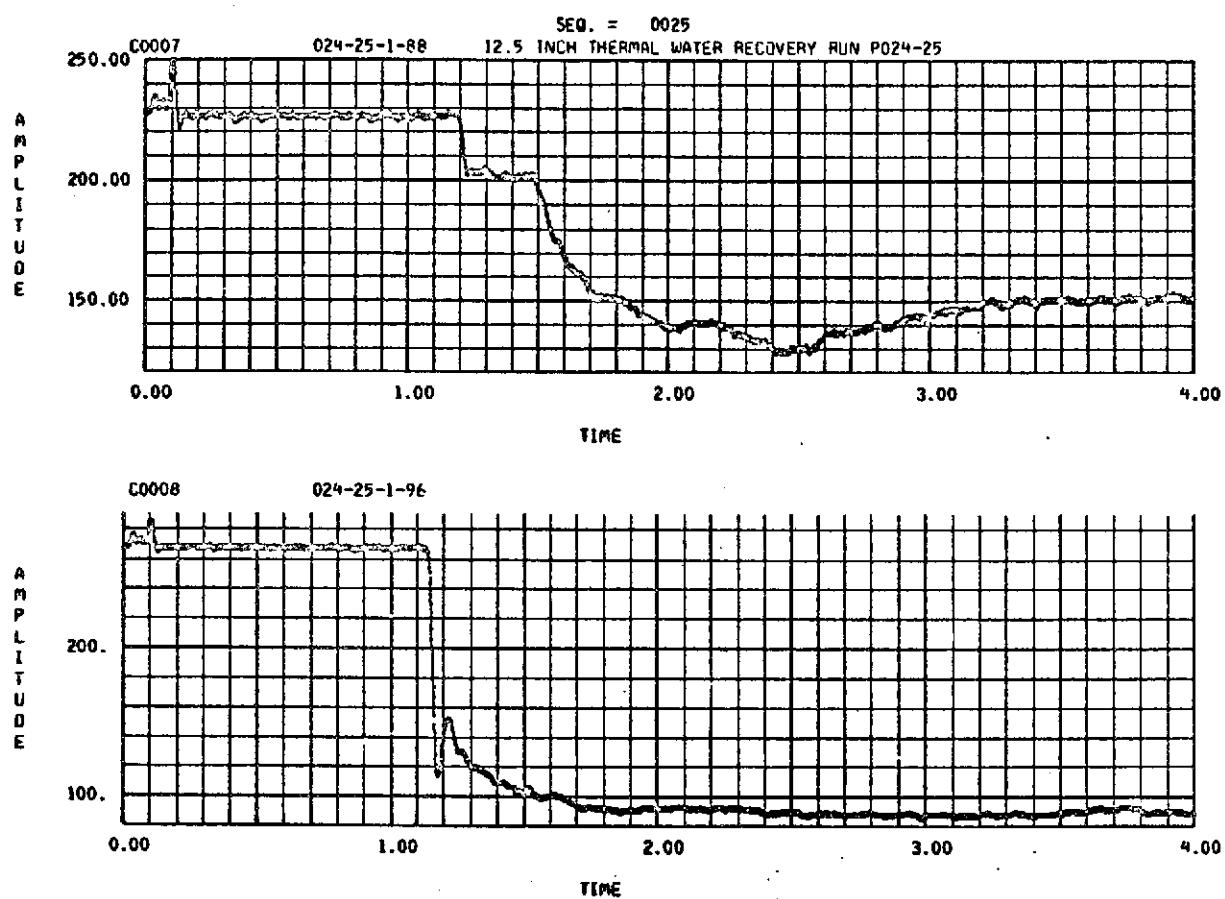
B-205

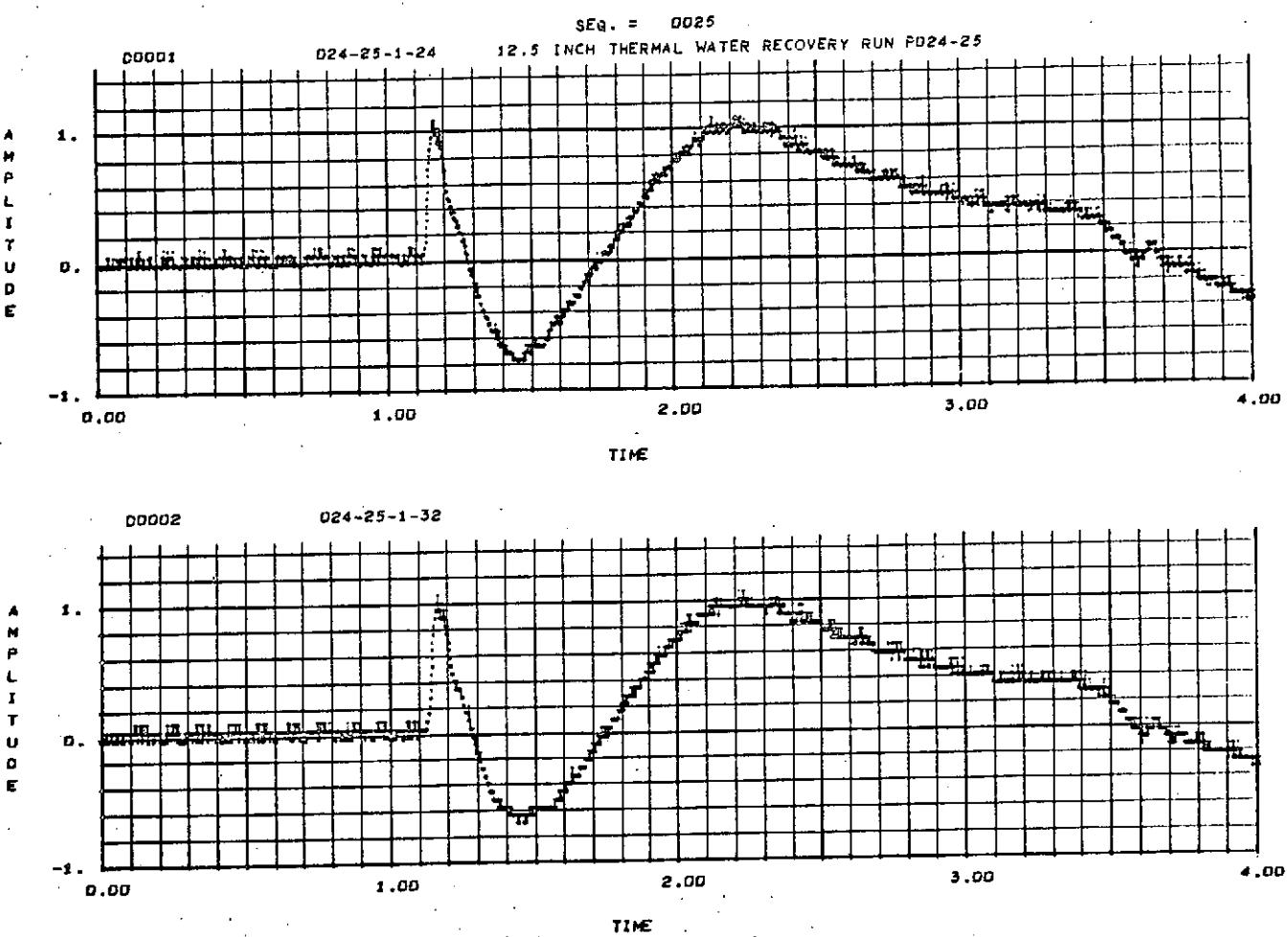
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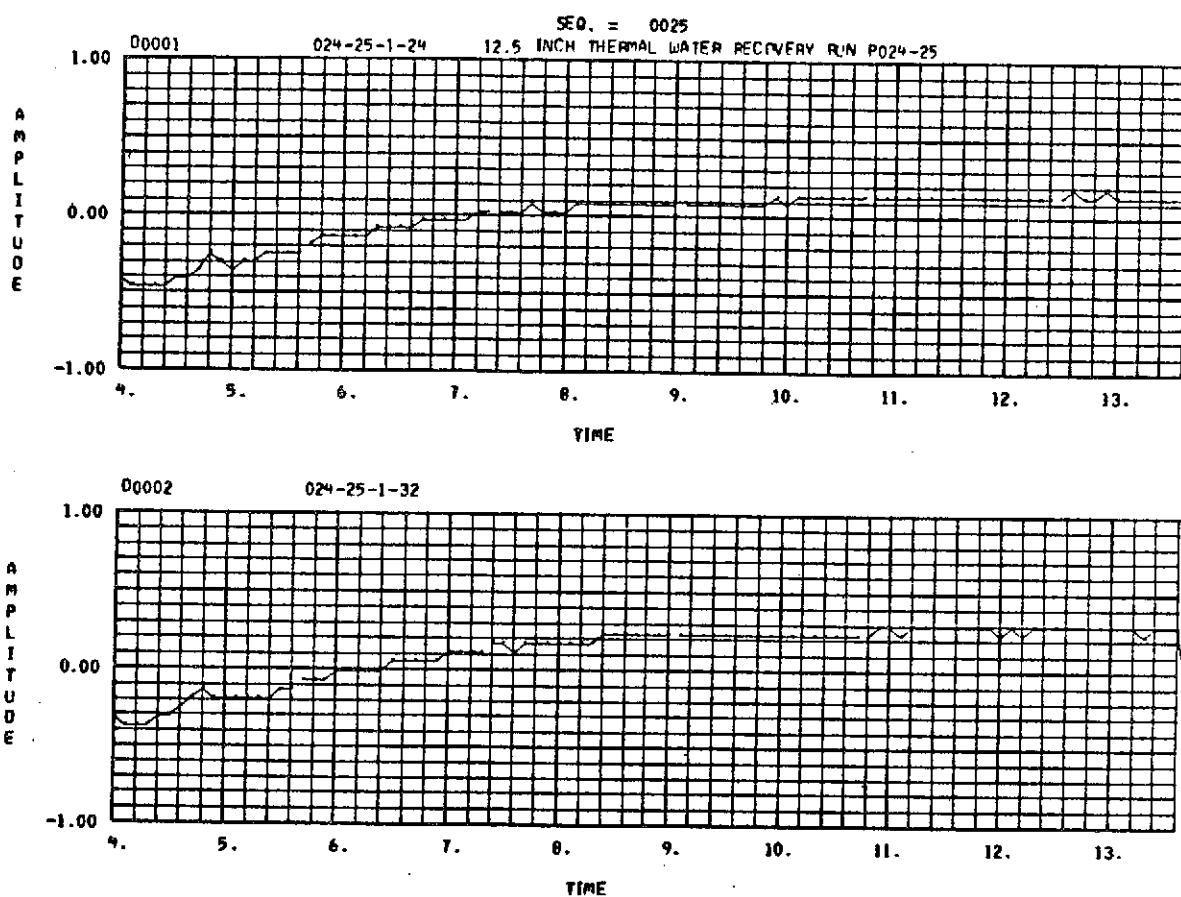
B-207 **REPRODUCIBILITY OF THE
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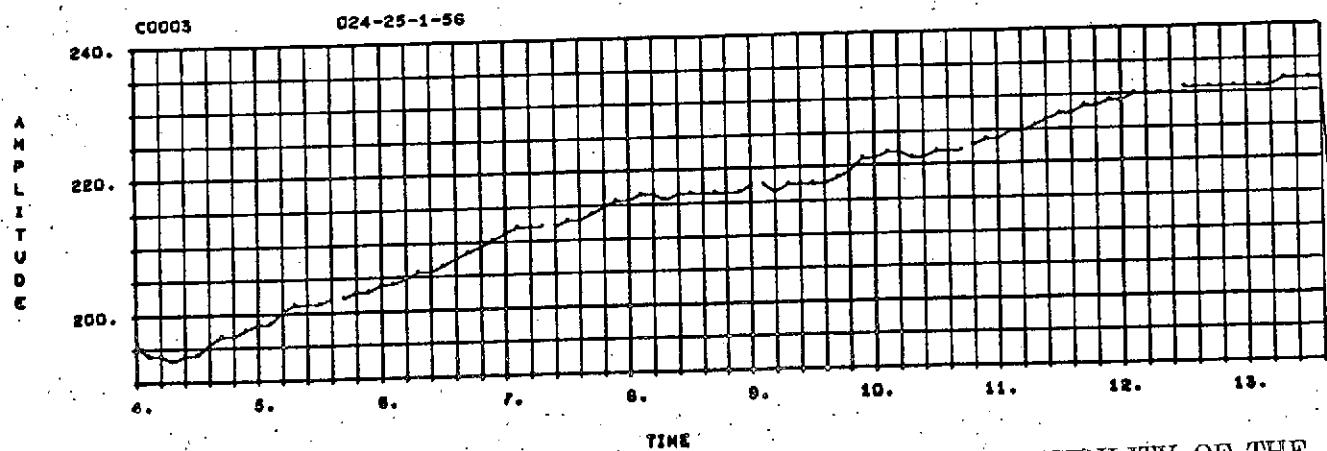
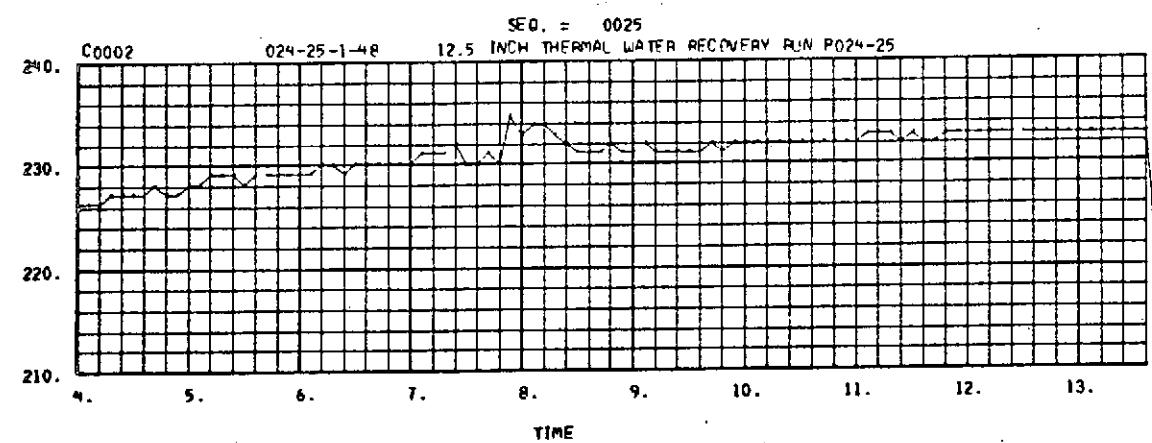
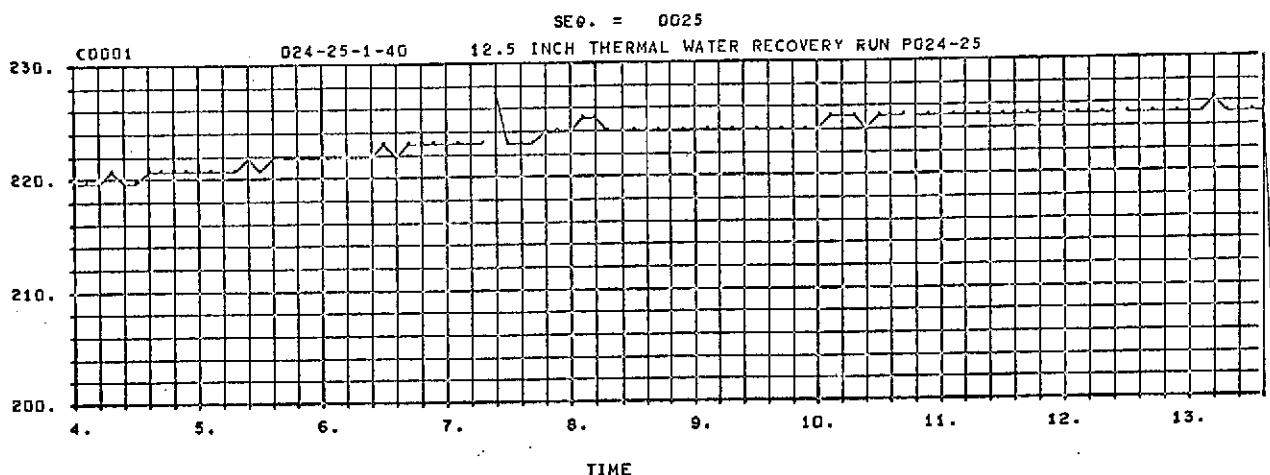




B-209

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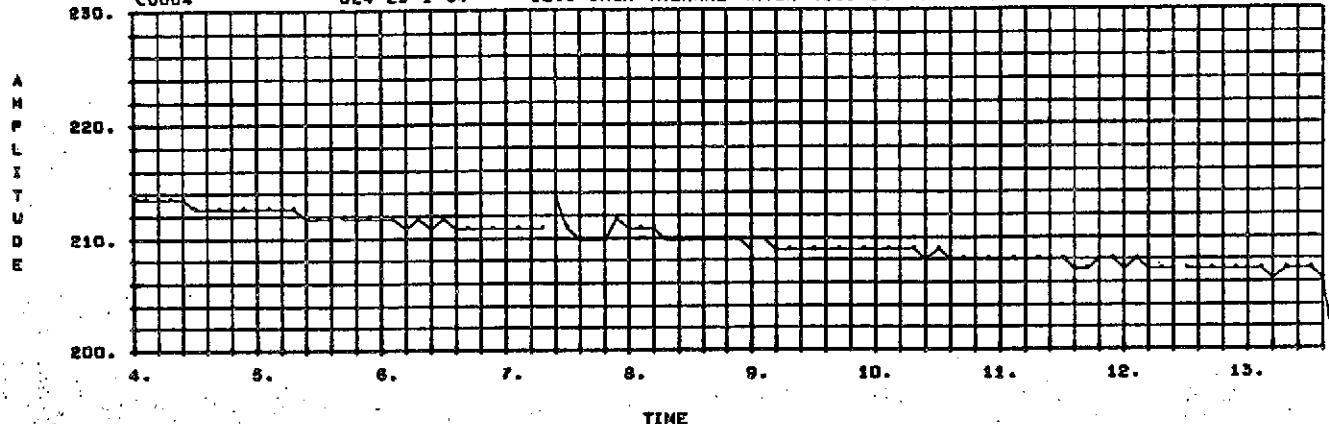


B-211

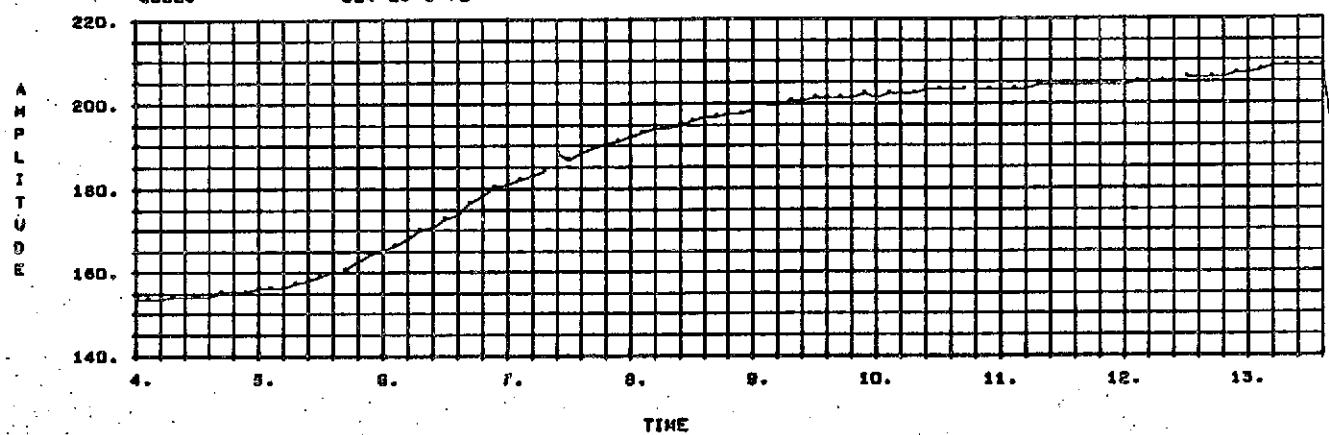
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SEQ. # 0025

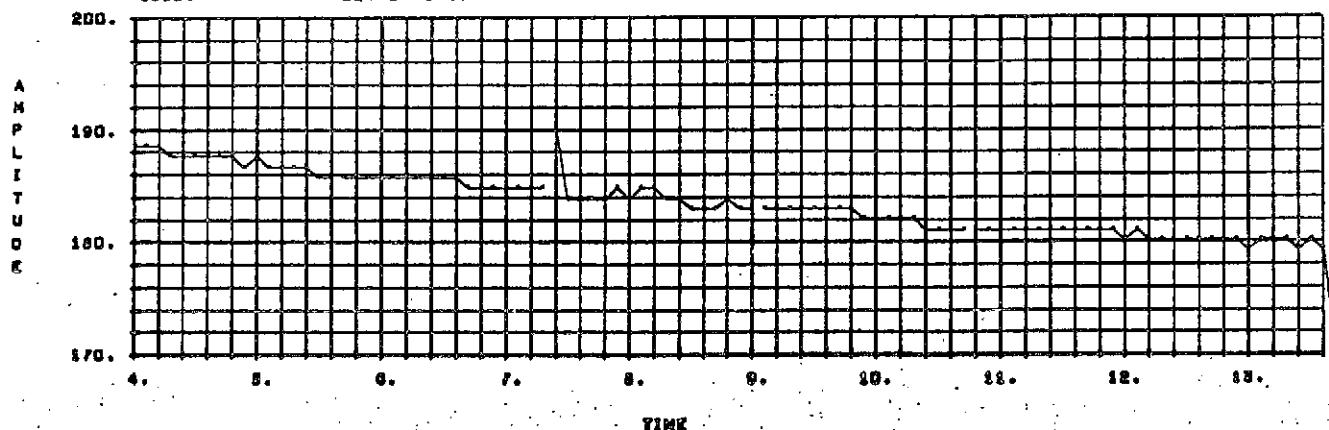
C0004 024-25-1-64 12.5 INCH THERMAL WATER RECOVERY RUN P024-25



C0005 024-25-1-72

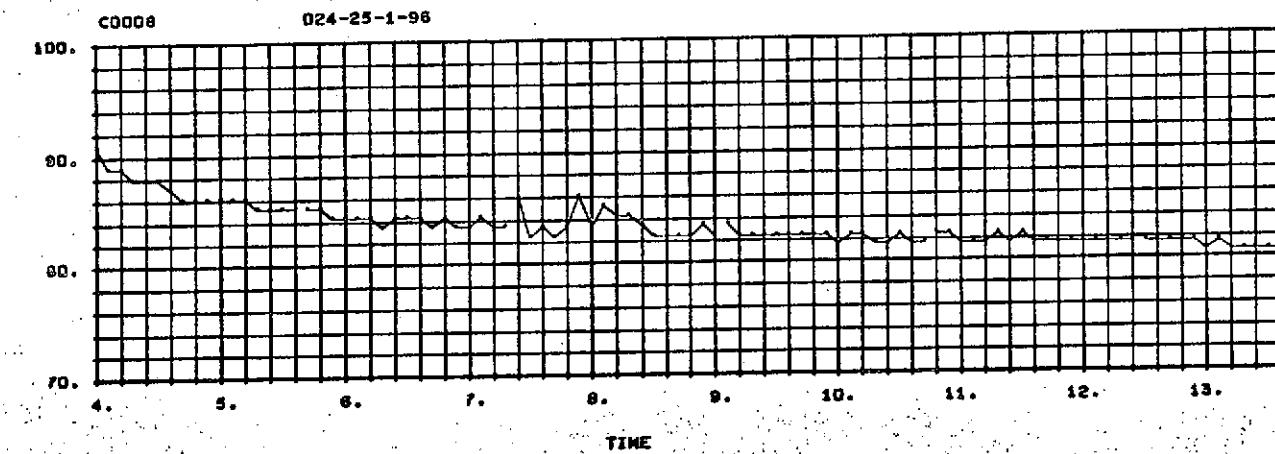
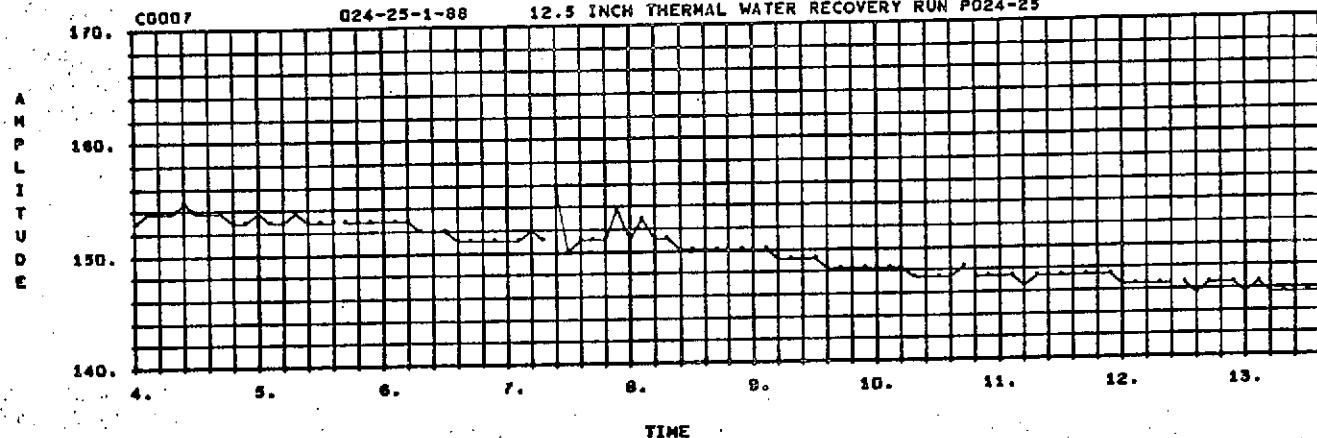


C0006 024-25-1-80



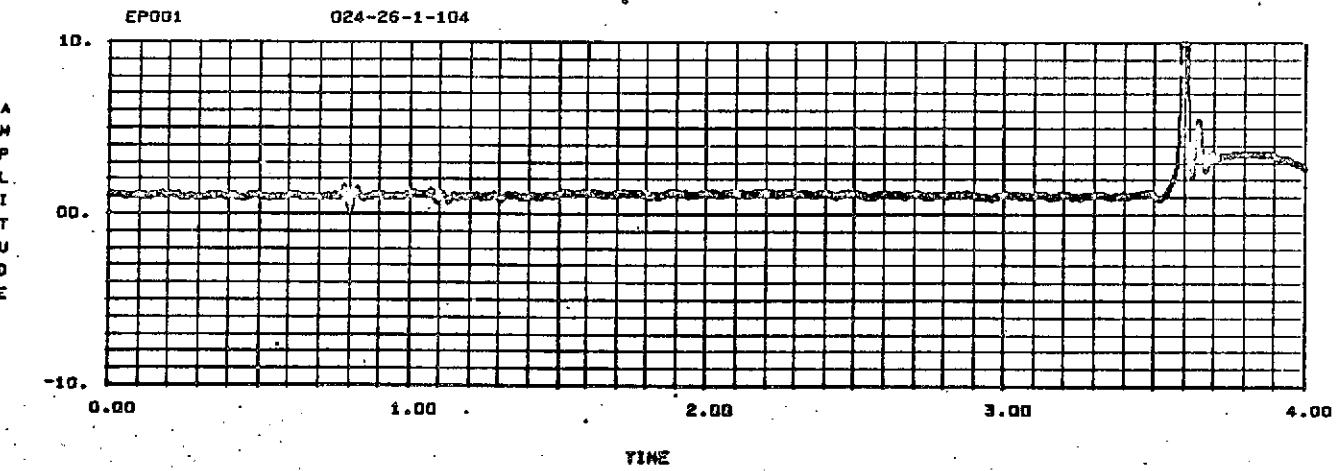
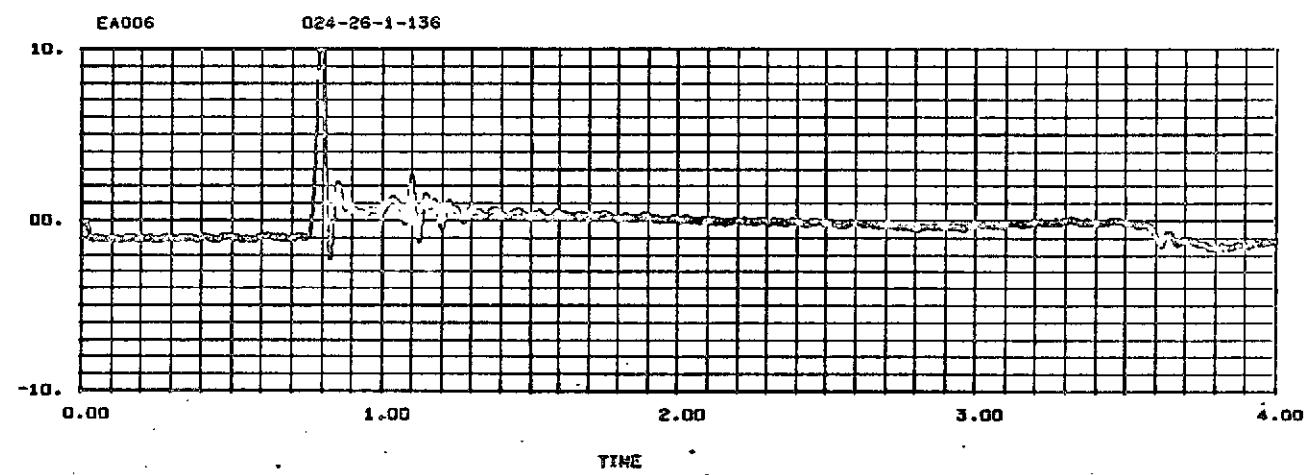
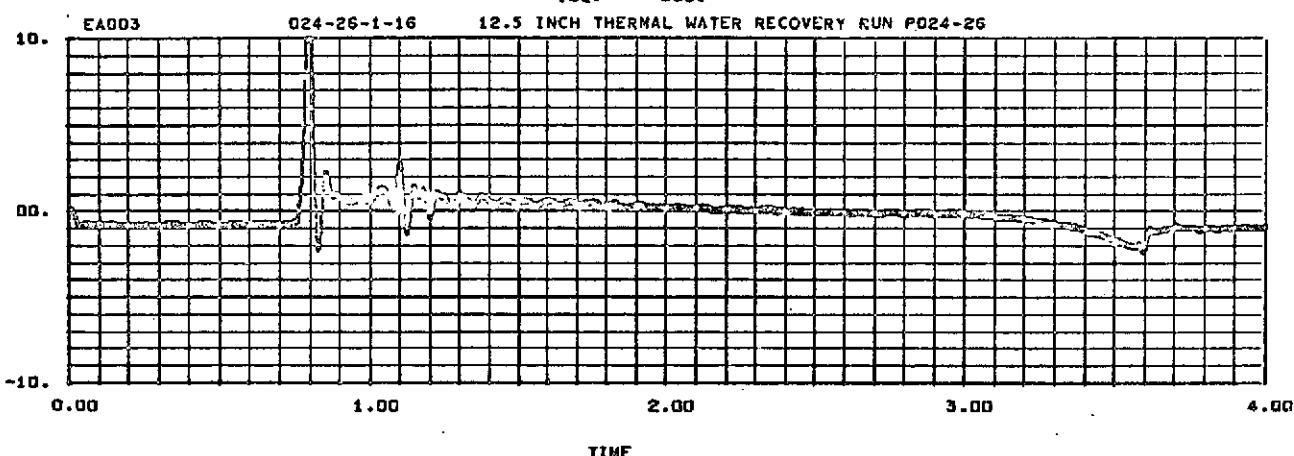
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024-25-1-88 12.5 INCH THERMAL WATER RECOVERY RUN P024-25



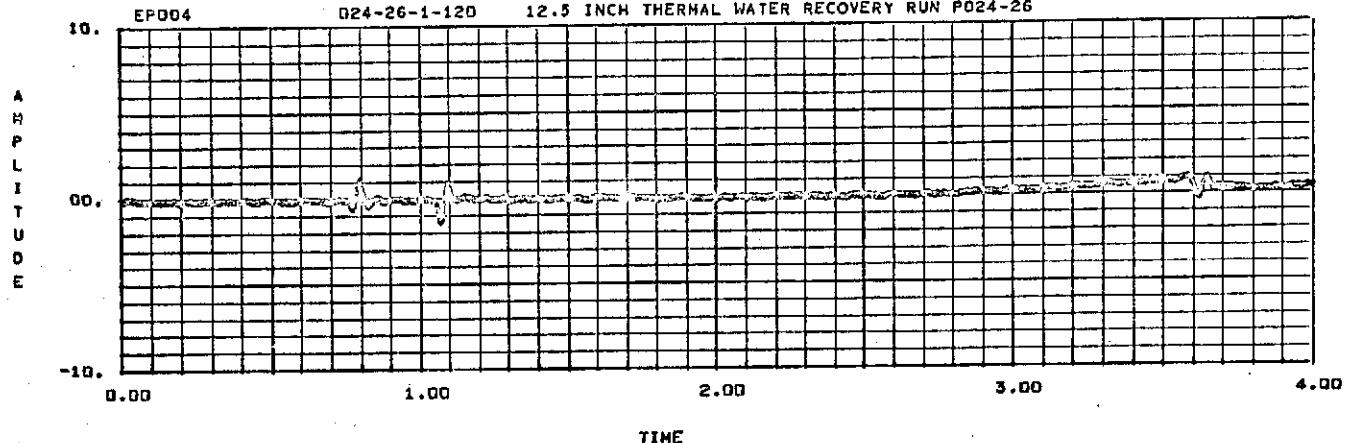
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SEQ. = 0026

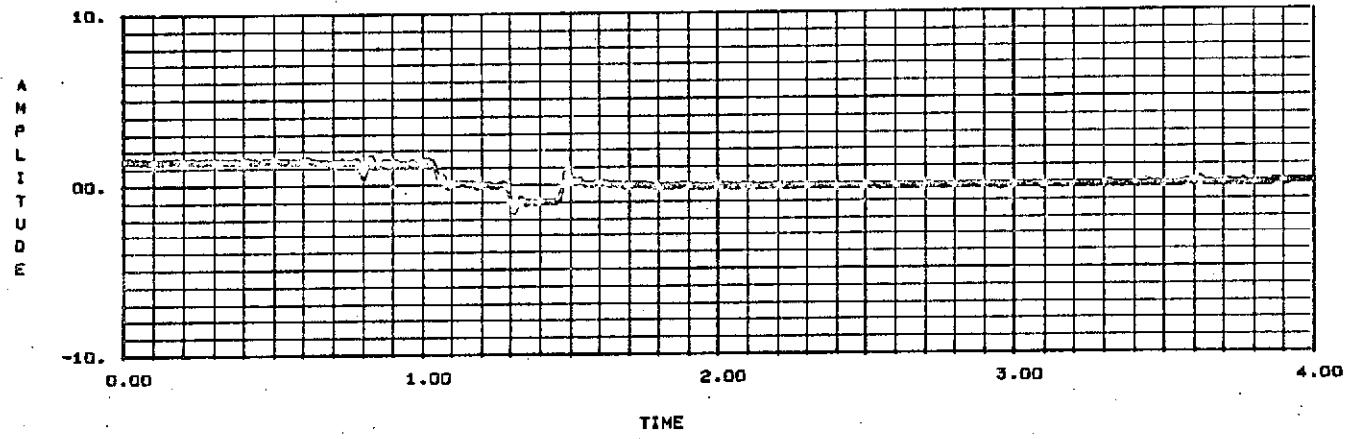


SEG. = 0026

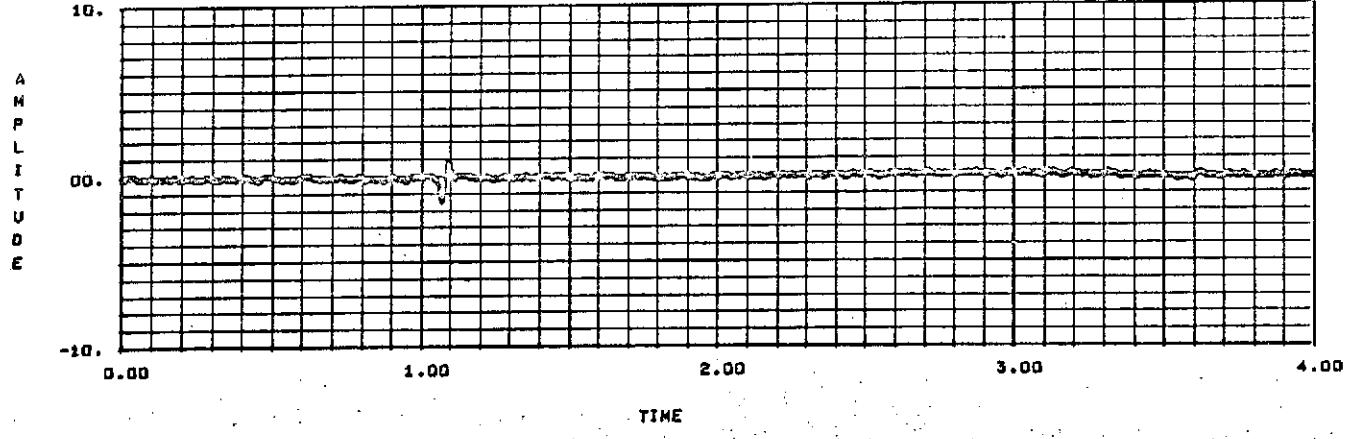
024-26-1-120 12.5 INCH THERMAL WATER RECOVERY RUN P024-26



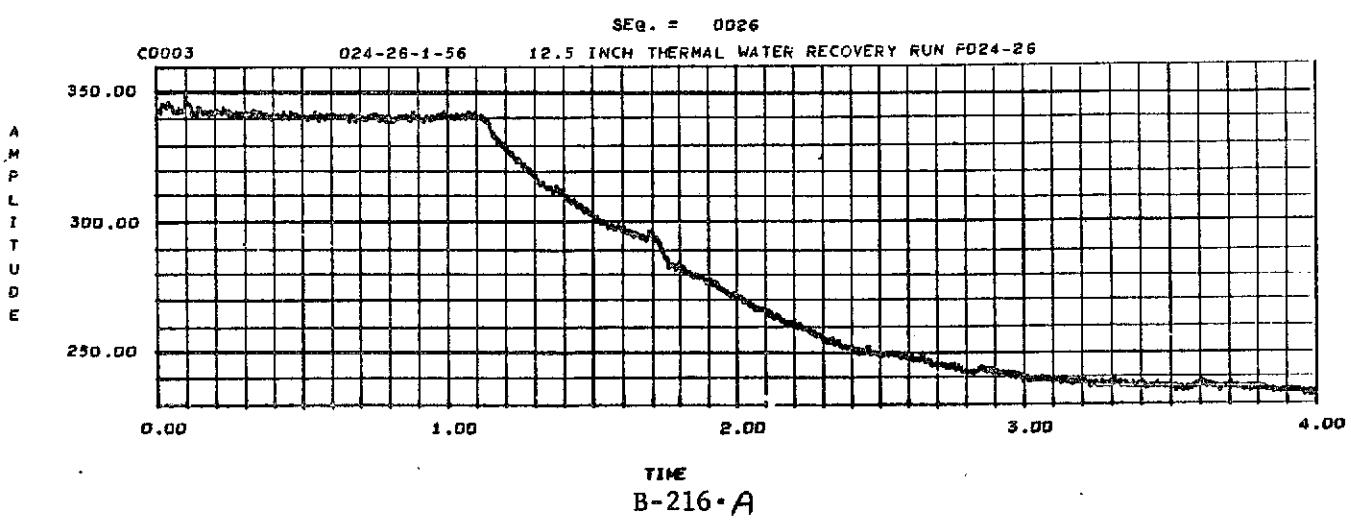
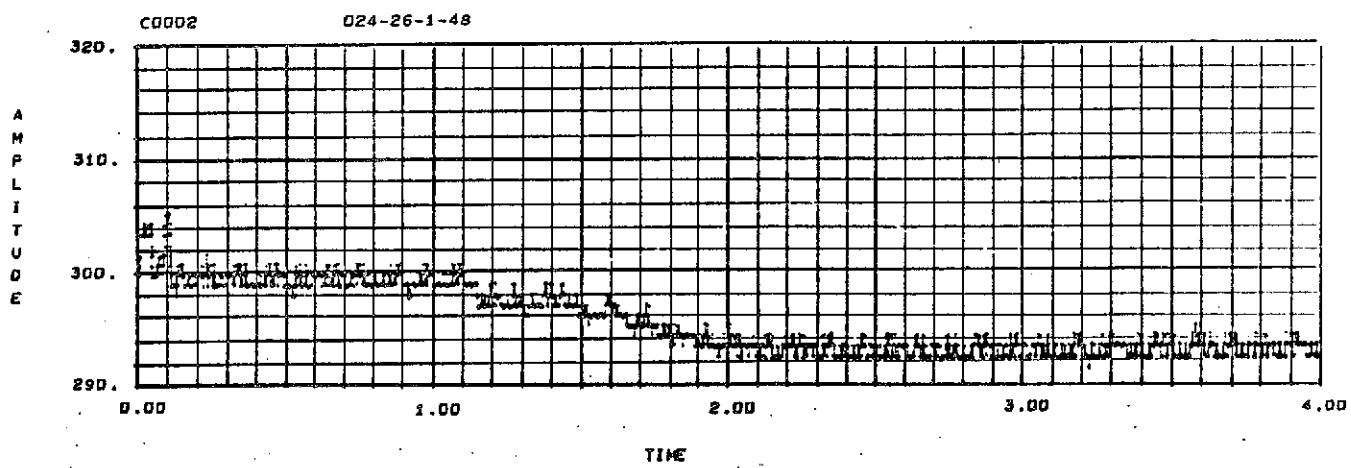
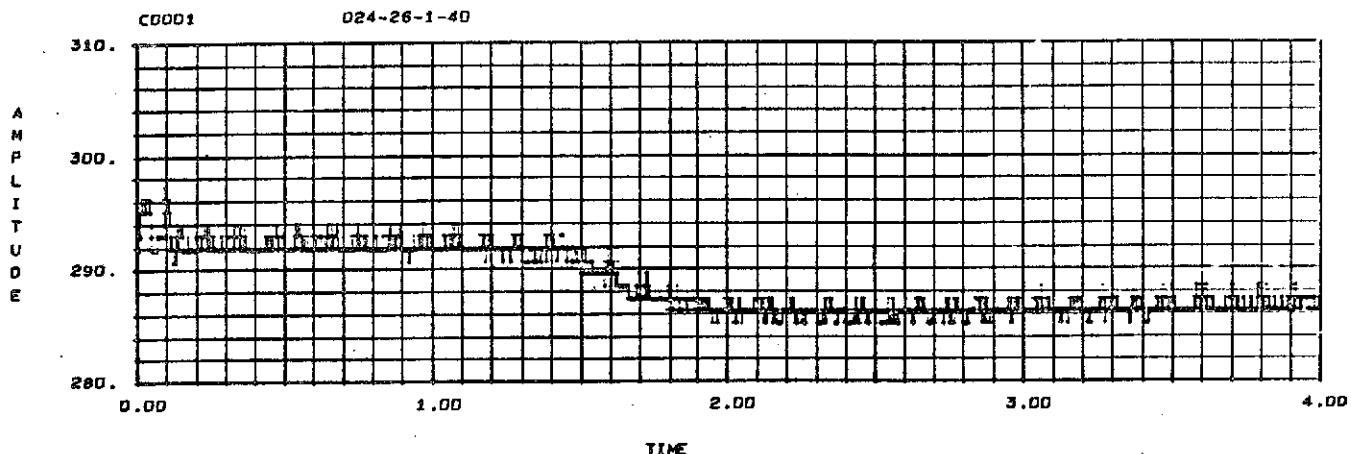
EY002 024-26-1-112



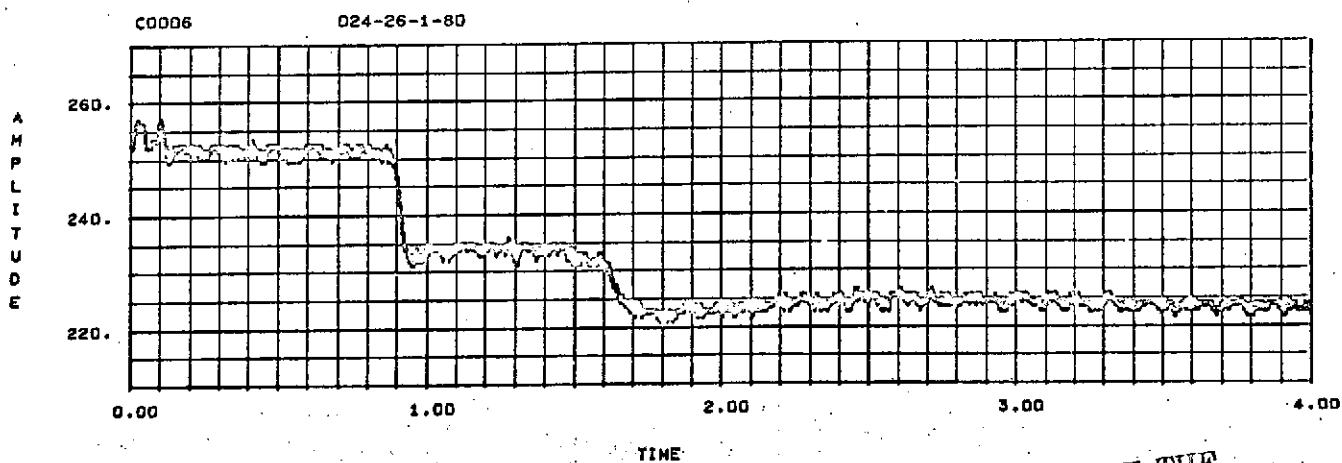
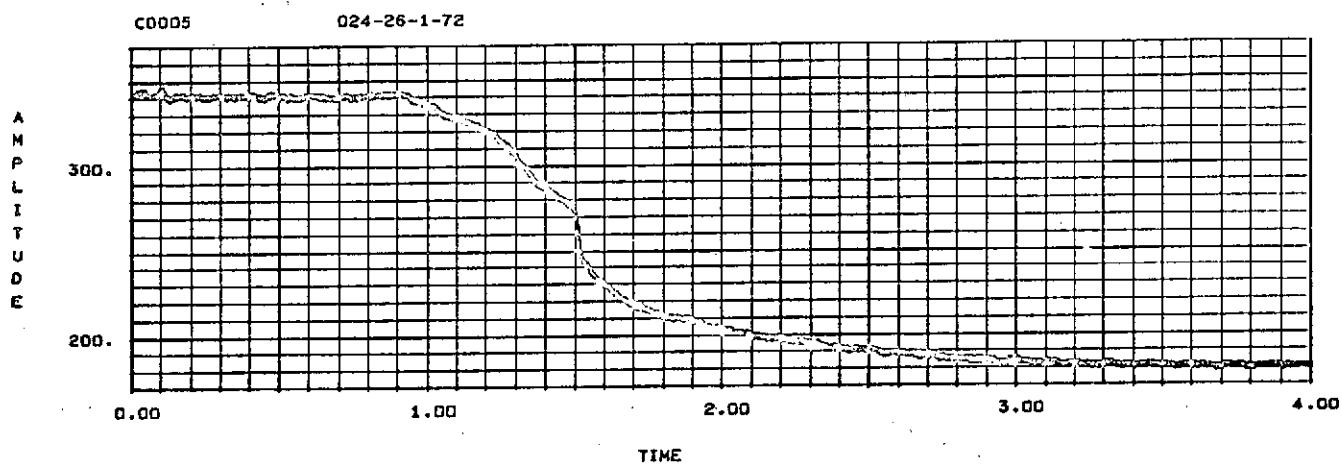
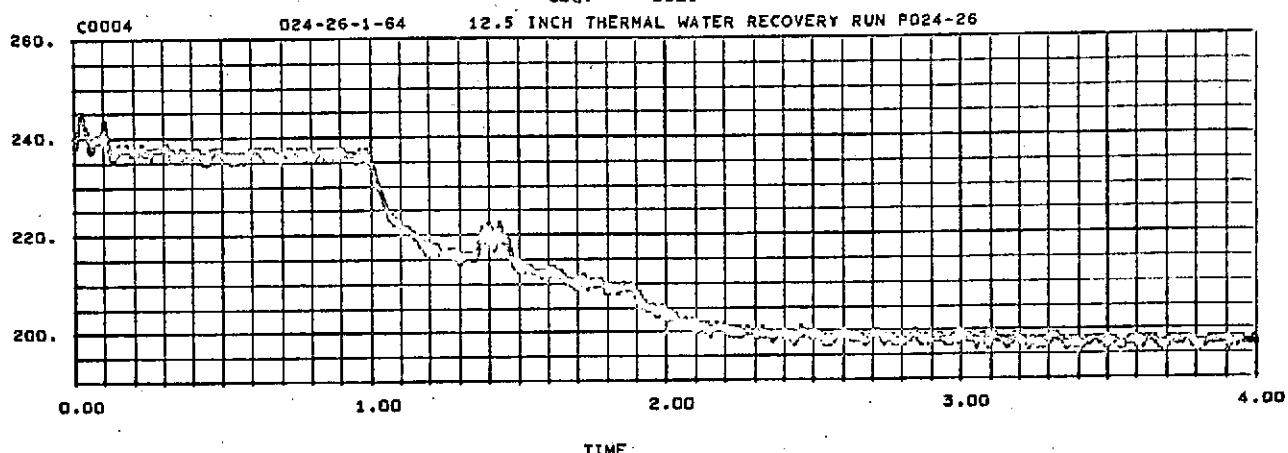
EY005 024-26-1-128



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ORIGINAL PAGE IS POOR



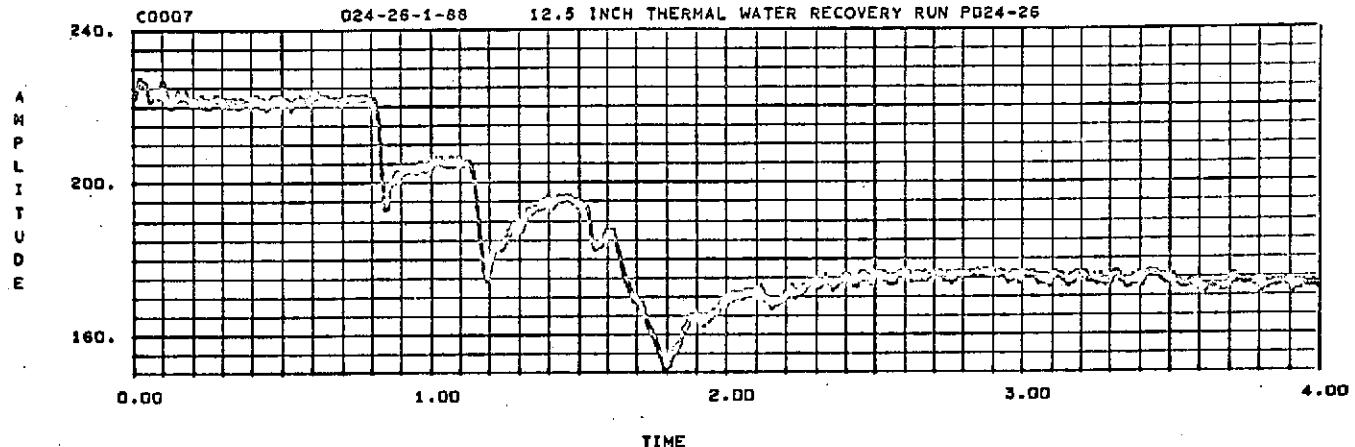
Sec. = 0026



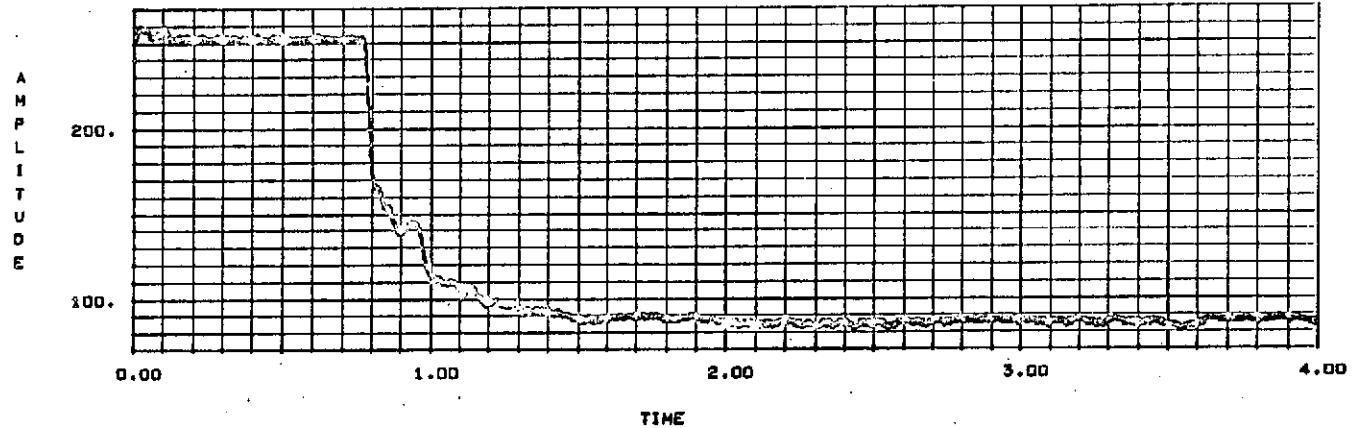
REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR!

SEQ. = 0026

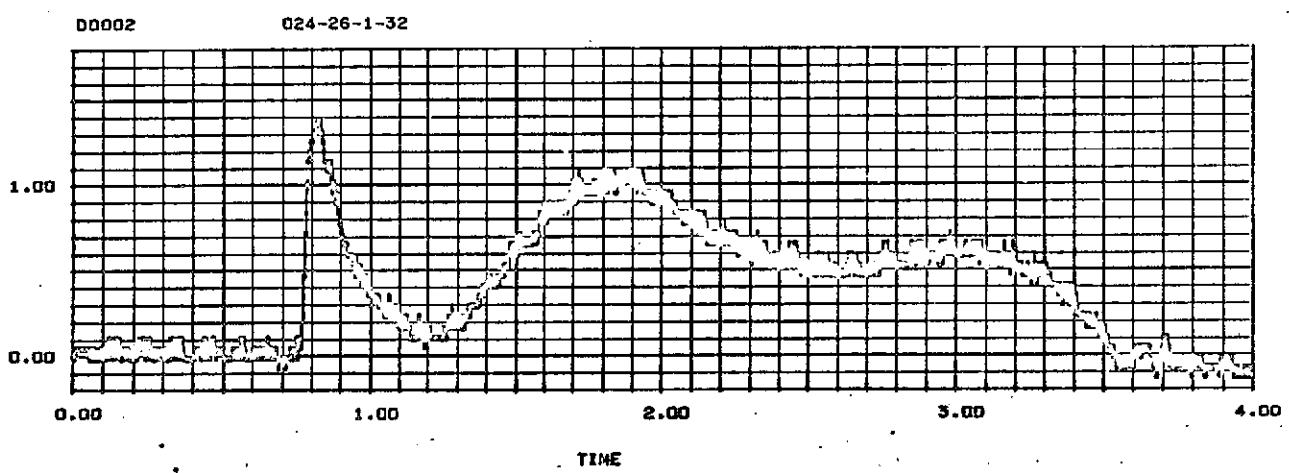
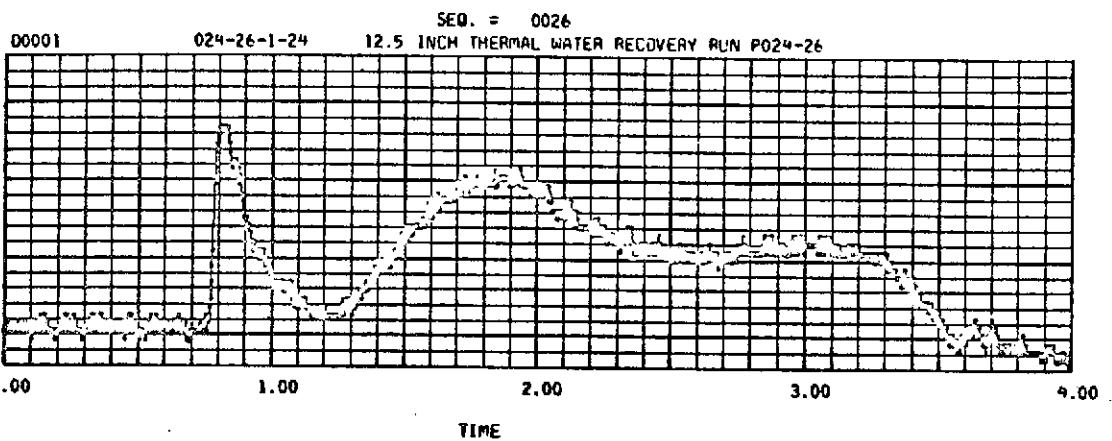
024-26-1-88 12.5 INCH THERMAL WATER RECOVERY RUN PD24-26

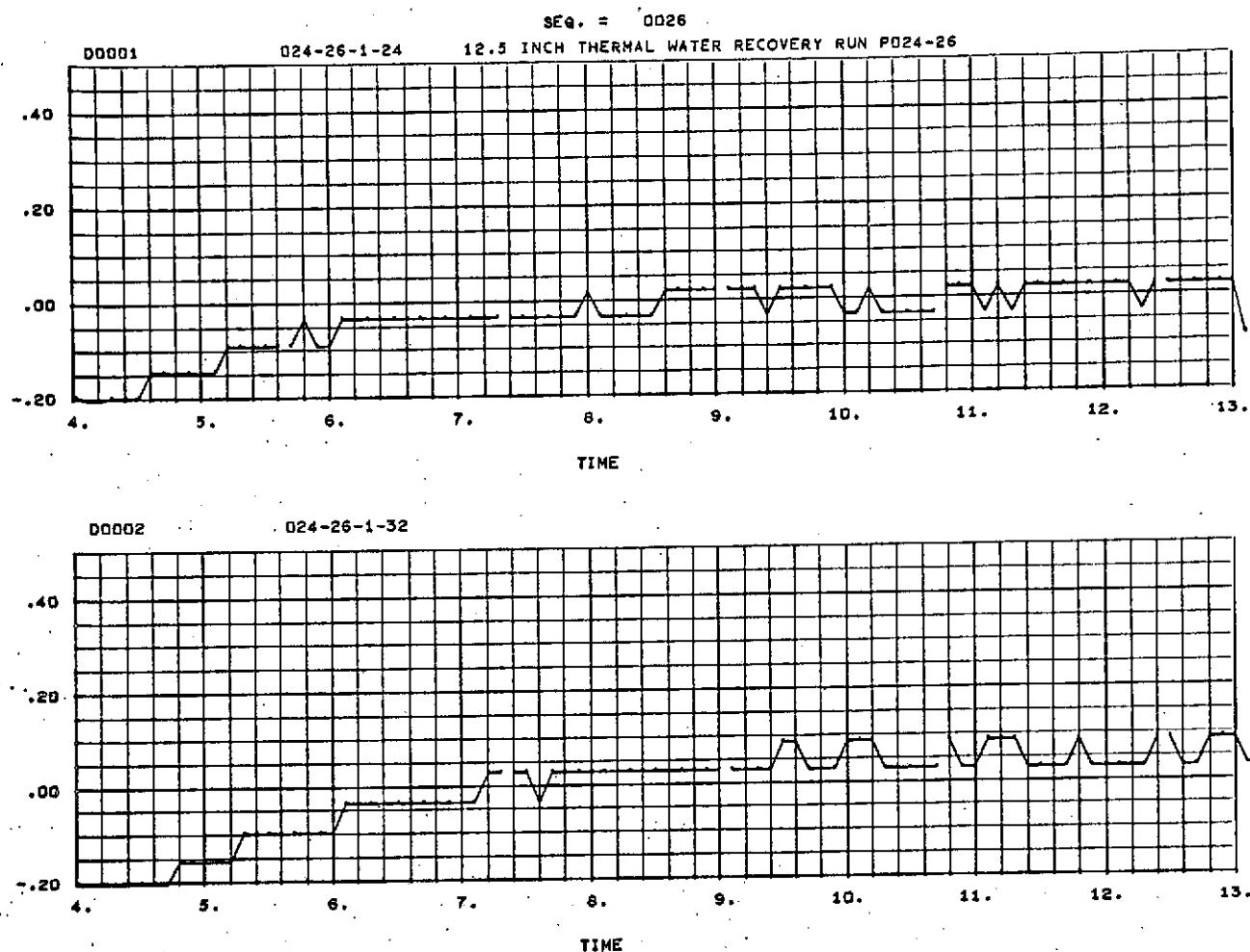


C0008 024-26-1-96

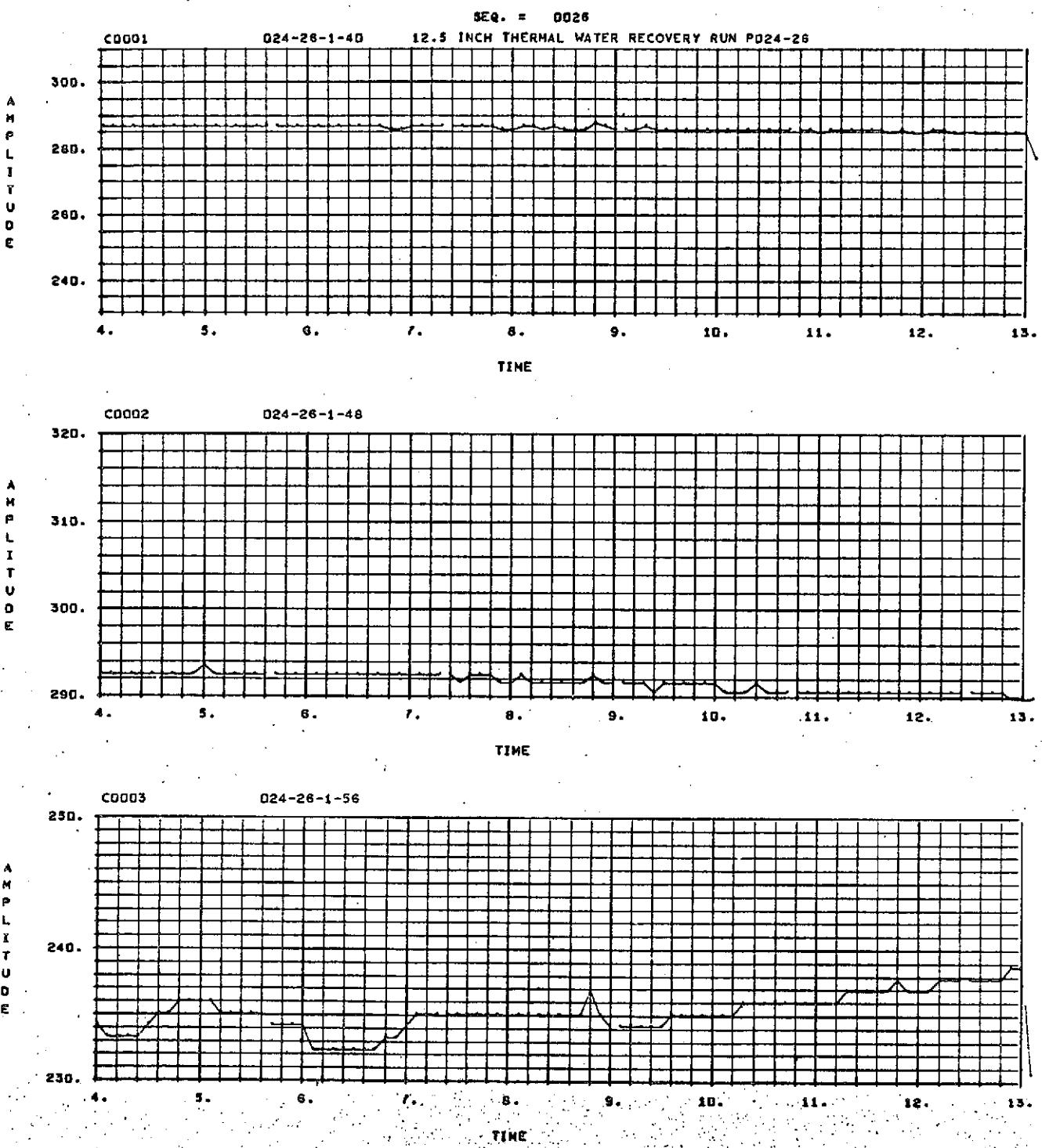


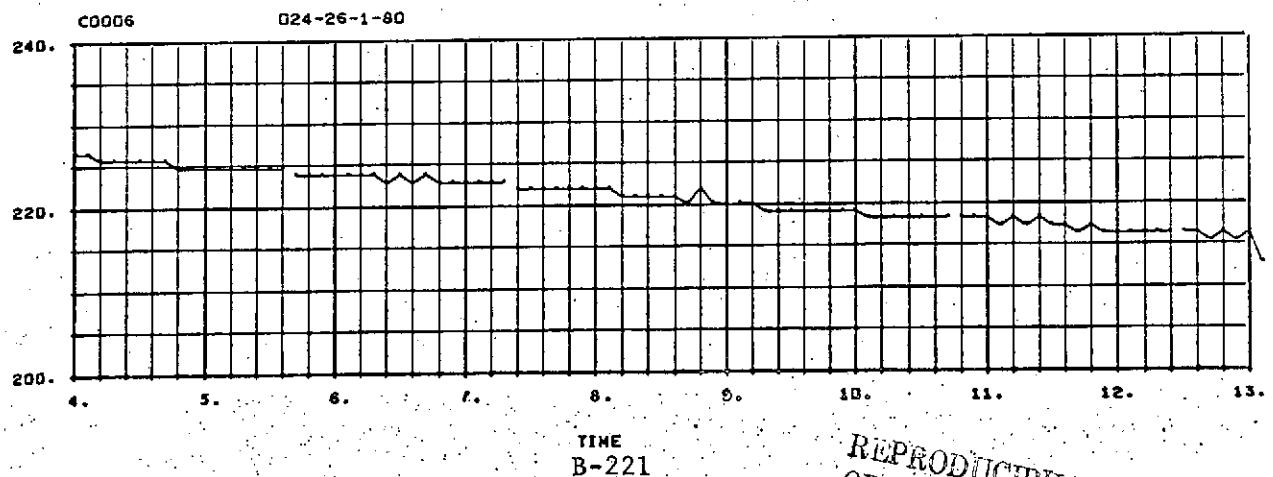
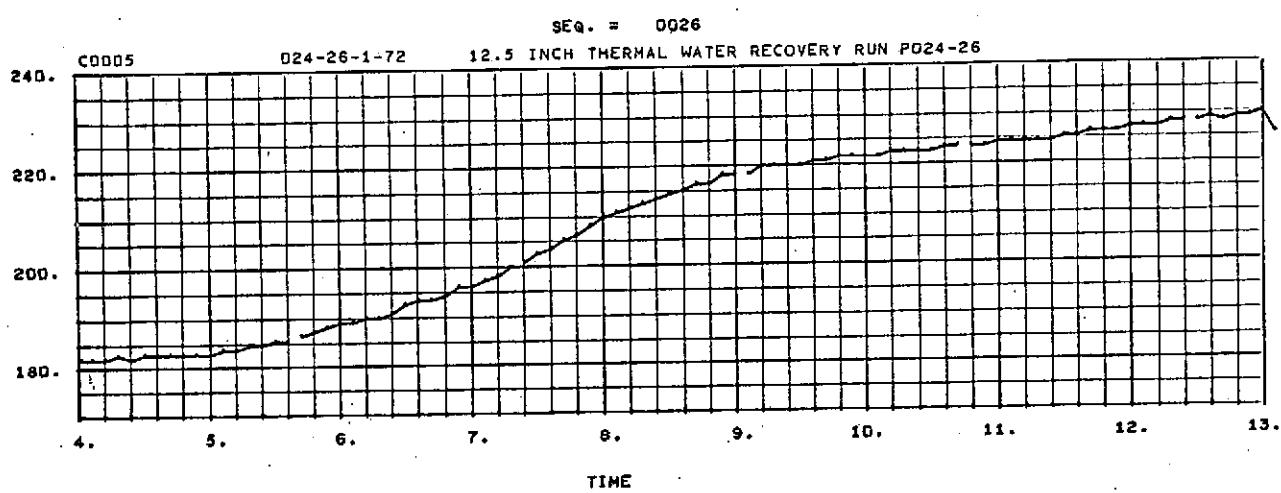
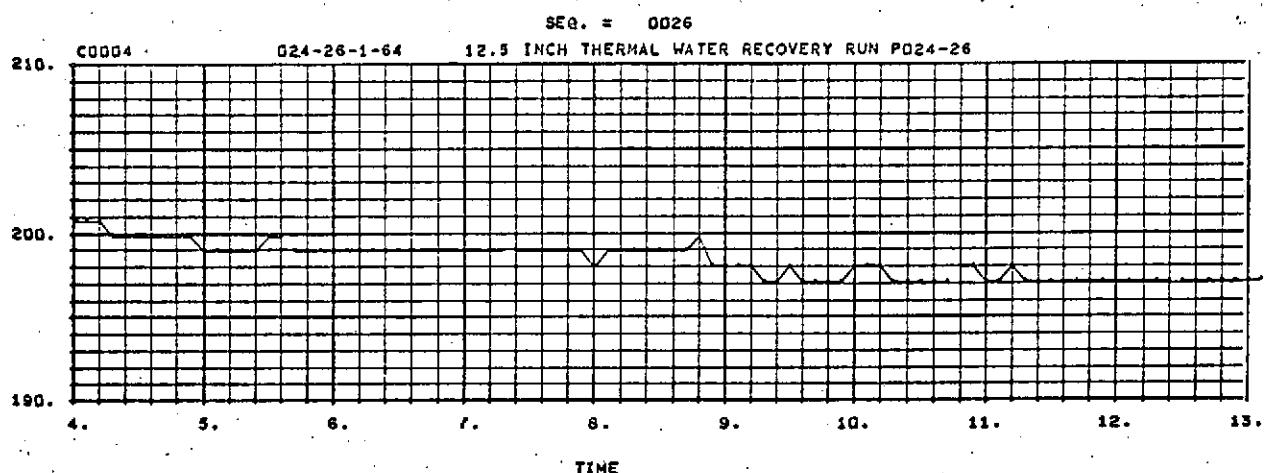
REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR



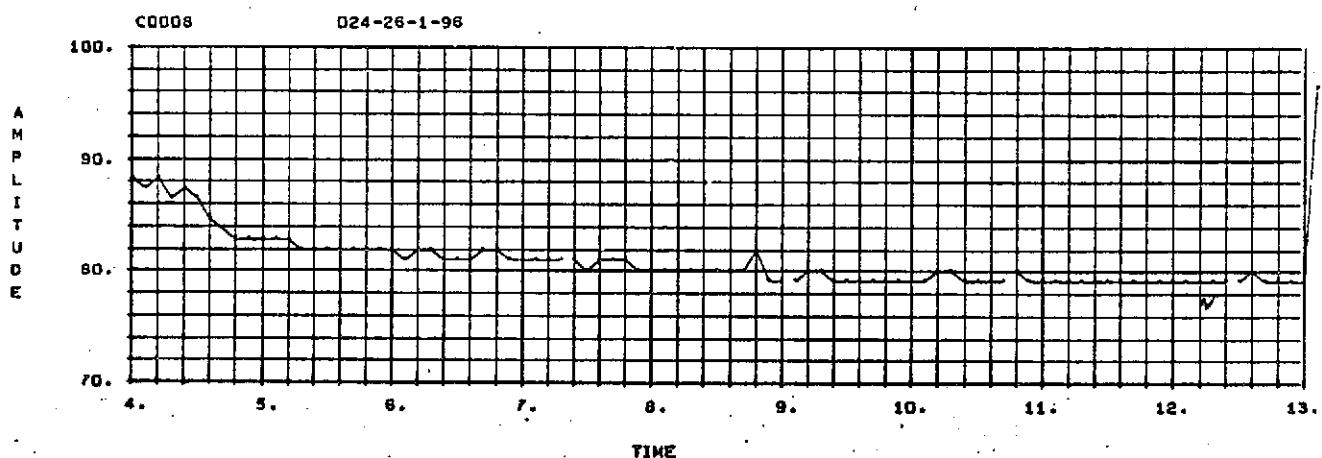
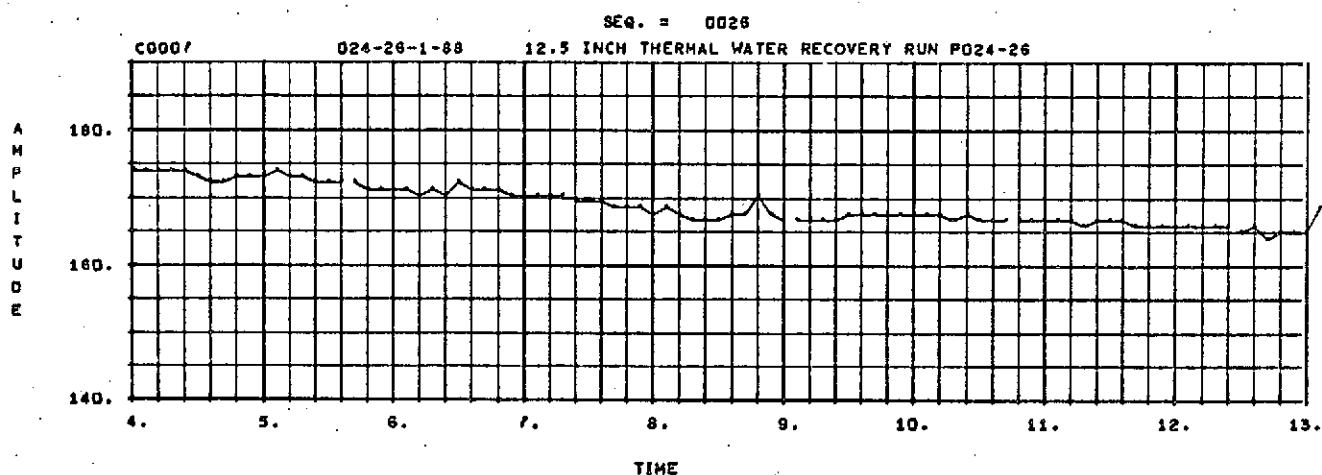


REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR





12.5 INCH THERMAL WATER RECOVERY RUN P024-26

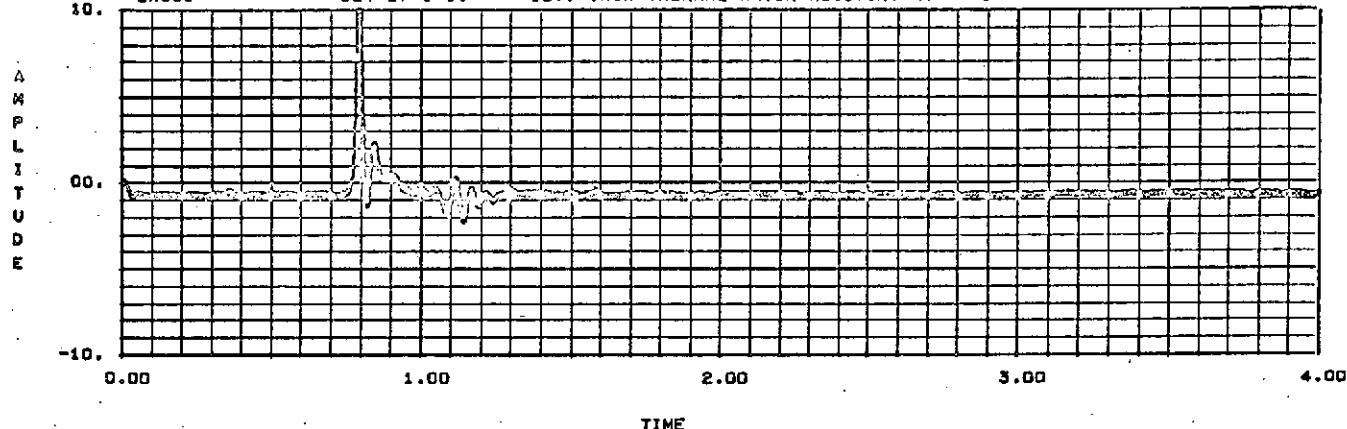


SEQ. = 0027

EA003

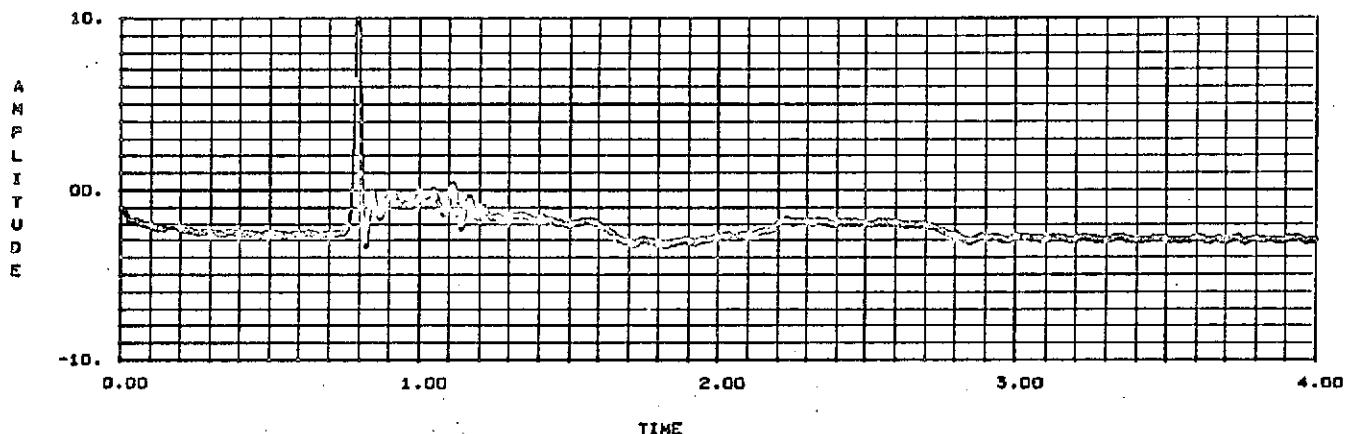
024-27-1-16

12.5 INCH THERMAL WATER RECOVERY RUN P024-27



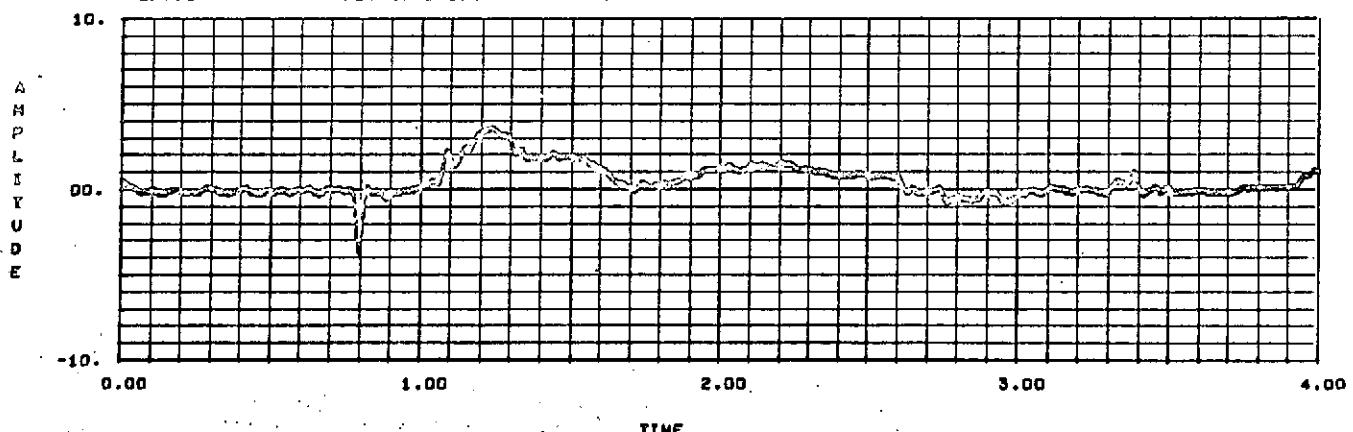
EA006

024-27-1-136



EP001

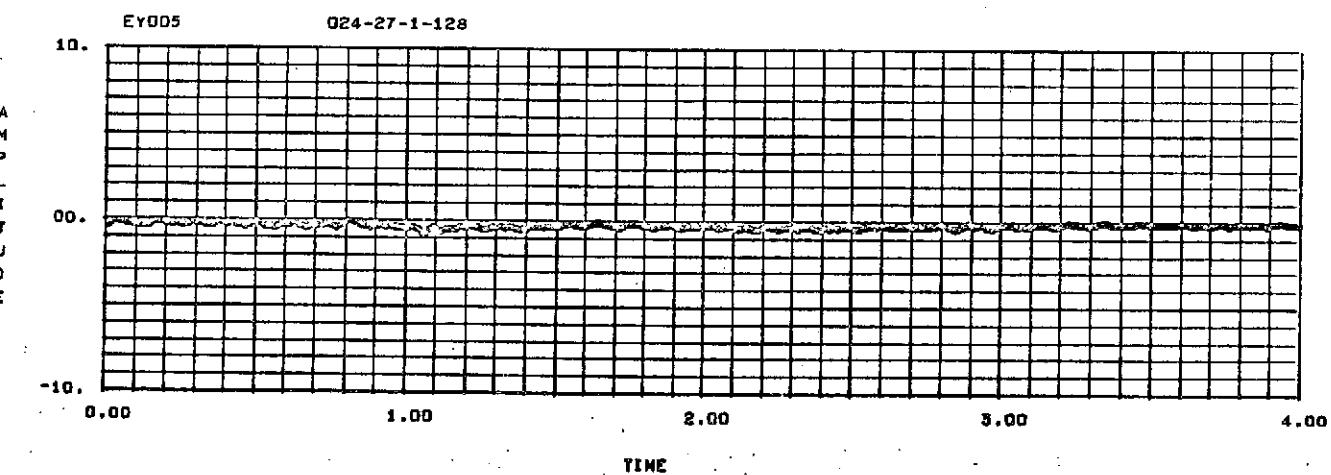
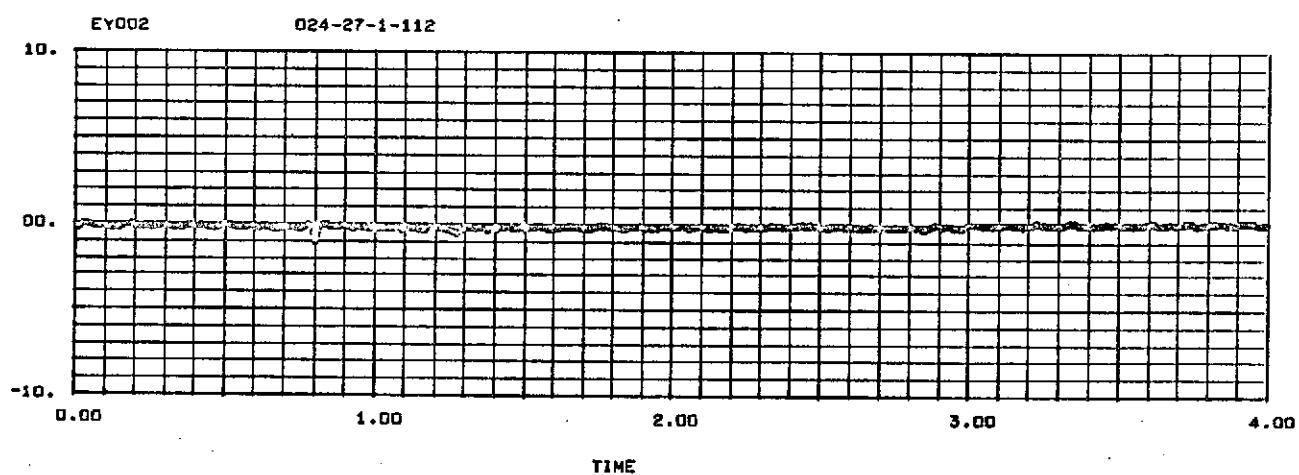
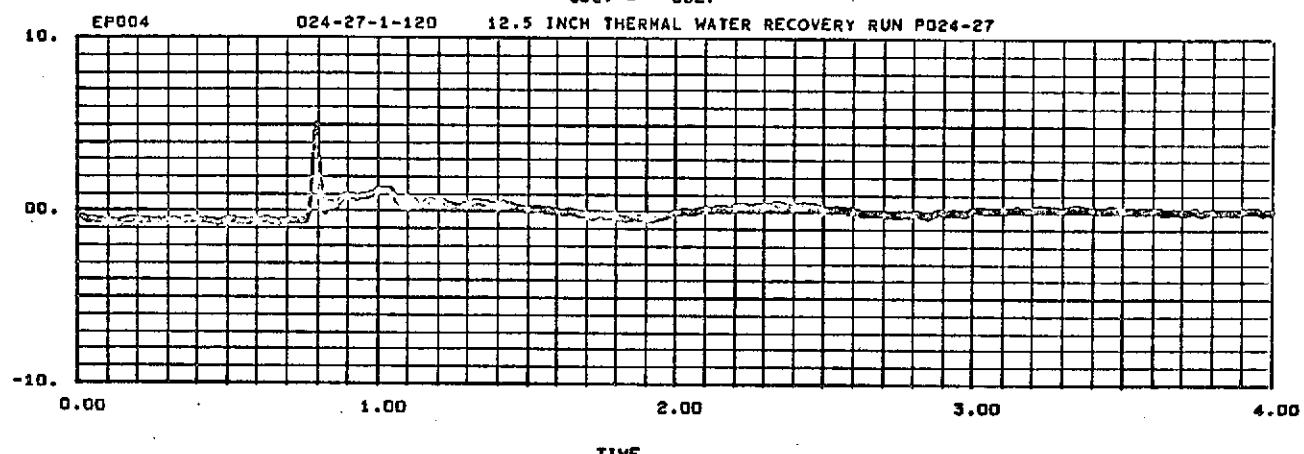
024-27-1-104

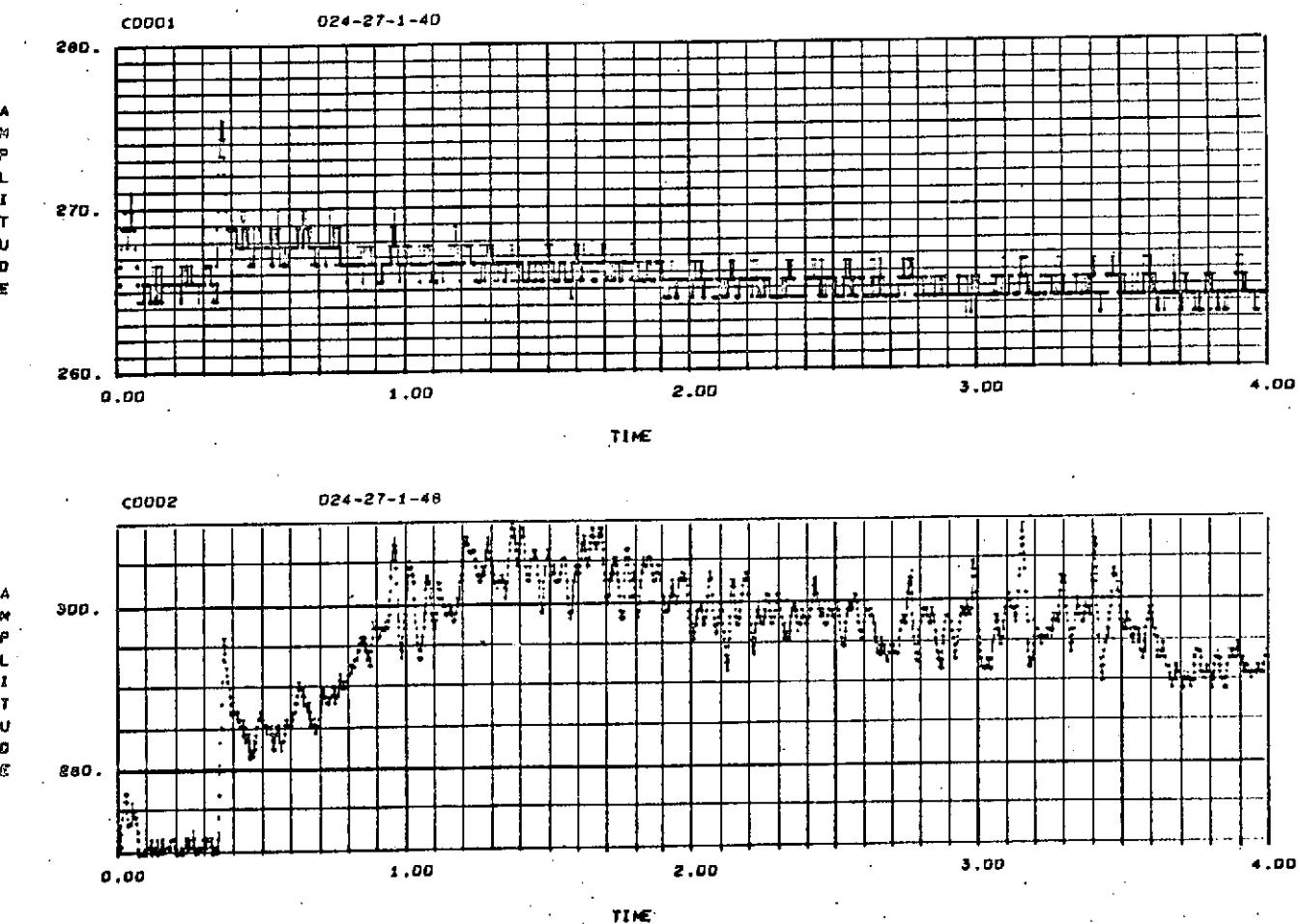


B-223

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

SEQ. = 0027

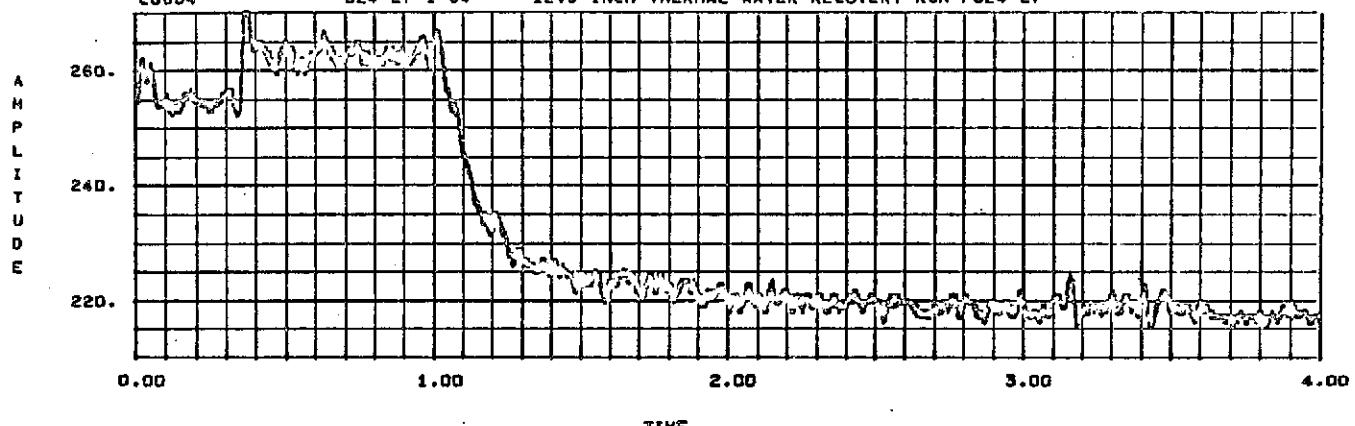




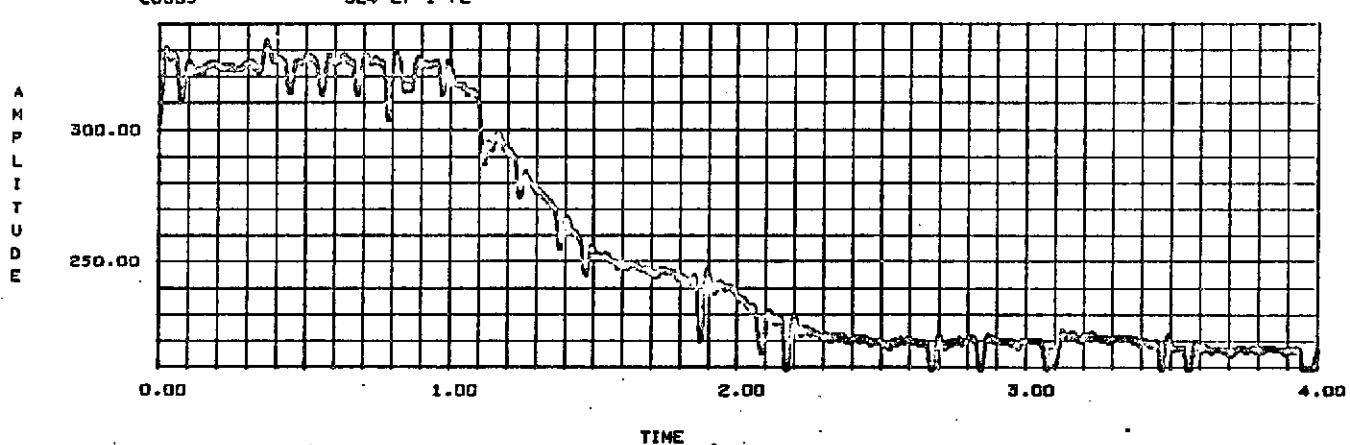
REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

SEQ. = 0027

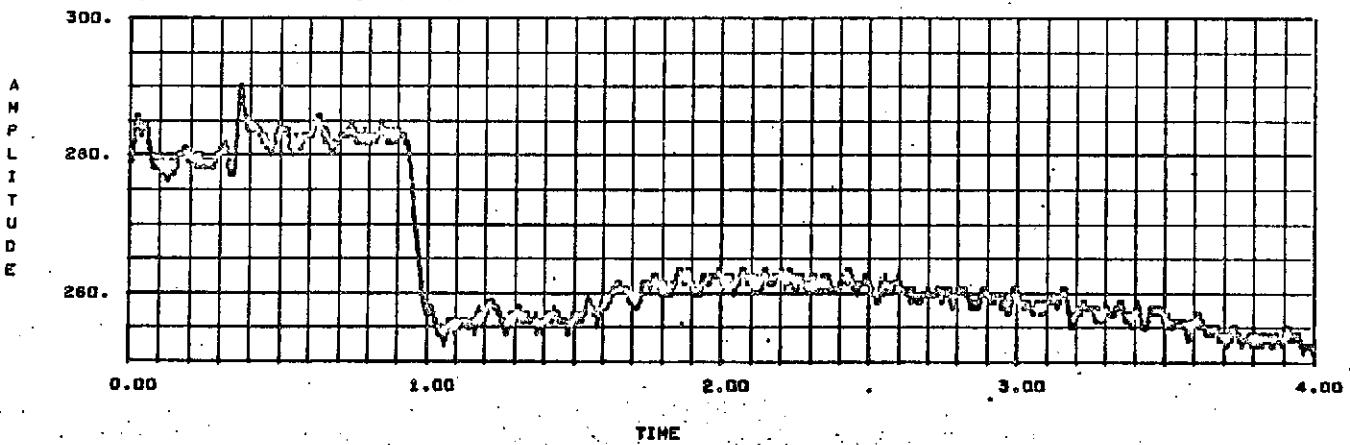
C0004 024-27-1-64 12.5 INCH THERMAL WATER RECOVERY RUN P024-27



C0005 024-27-1-72



C0006 024-27-1-80



B-226

SEQ. = 0027

C0007

024-27-1-88

12.5 INCH THERMAL WATER RECOVERY RUN P024-27

AMPLITUDE

260.
240.
220.
200.

0.00

1.00

2.00

3.00

4.00

TIME

C0008

024-27-1-96

AMPLITUDE

250.00
200.00
150.00
100.00

0.00

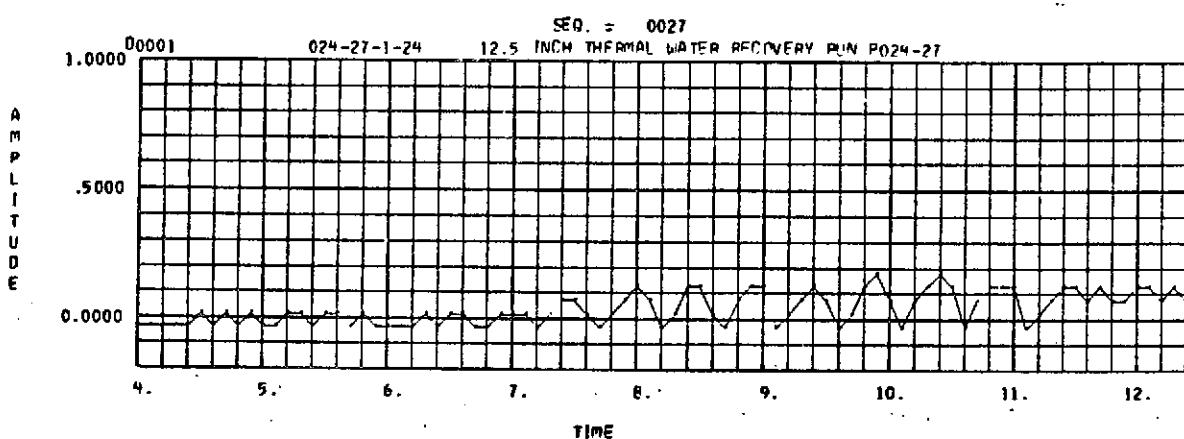
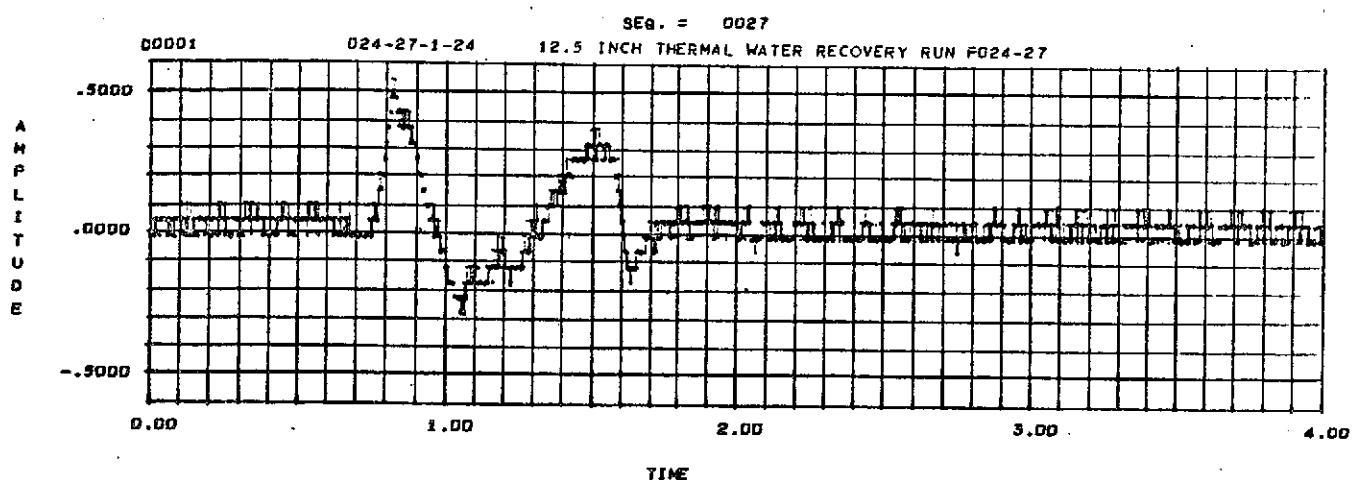
1.00

2.00

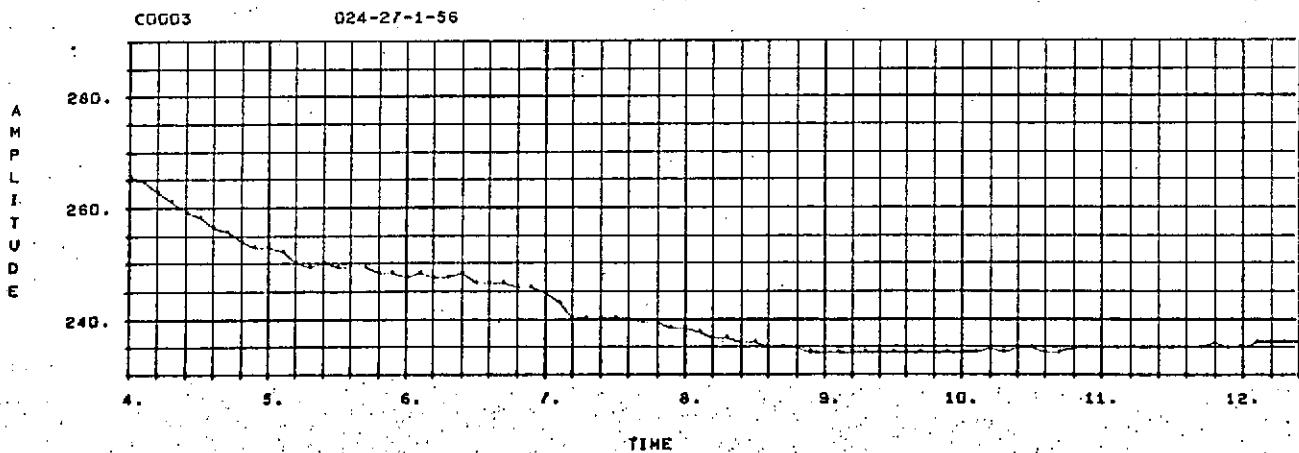
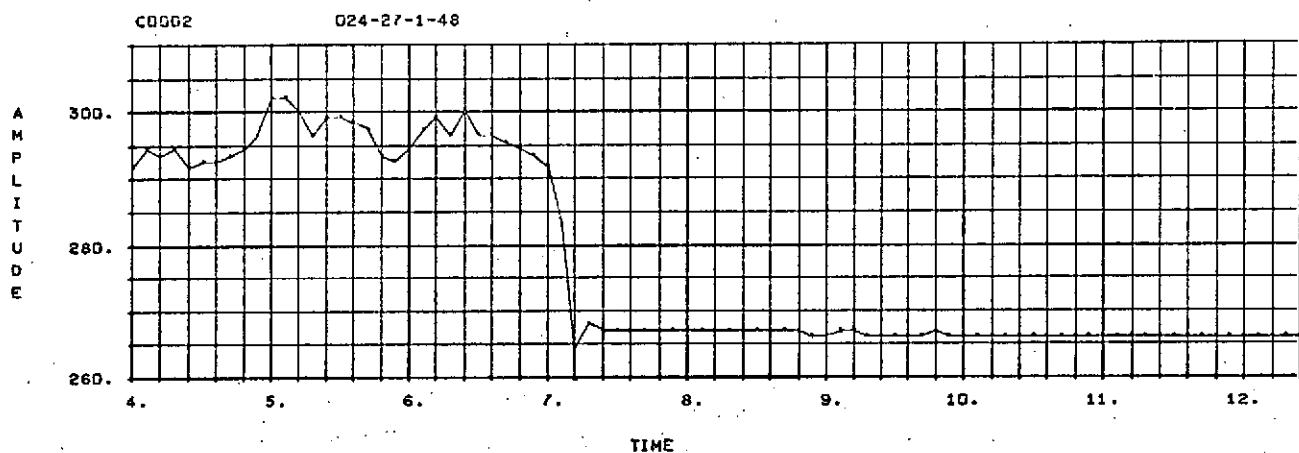
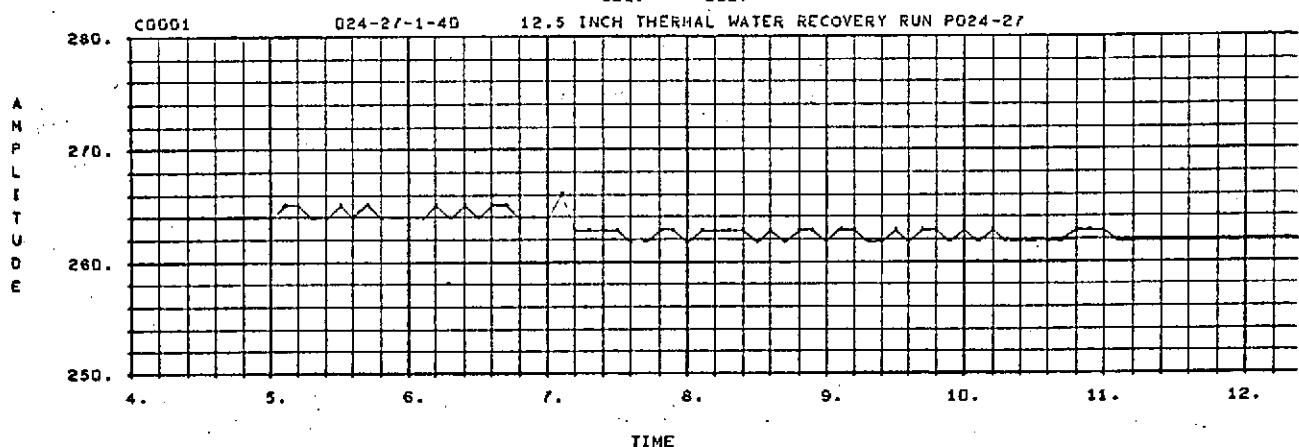
3.00

4.00

TIME

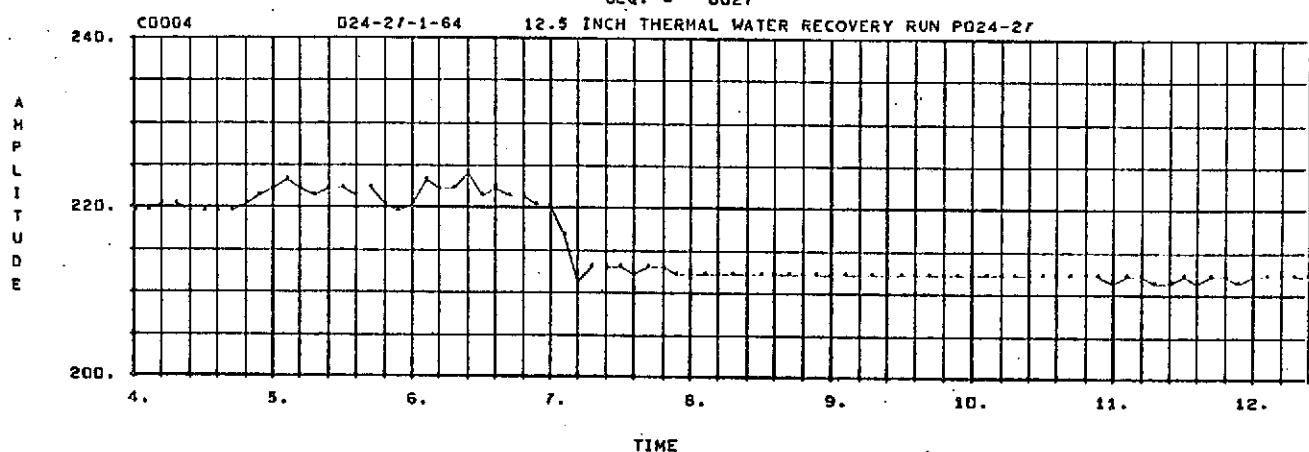


SEQ. = 0027



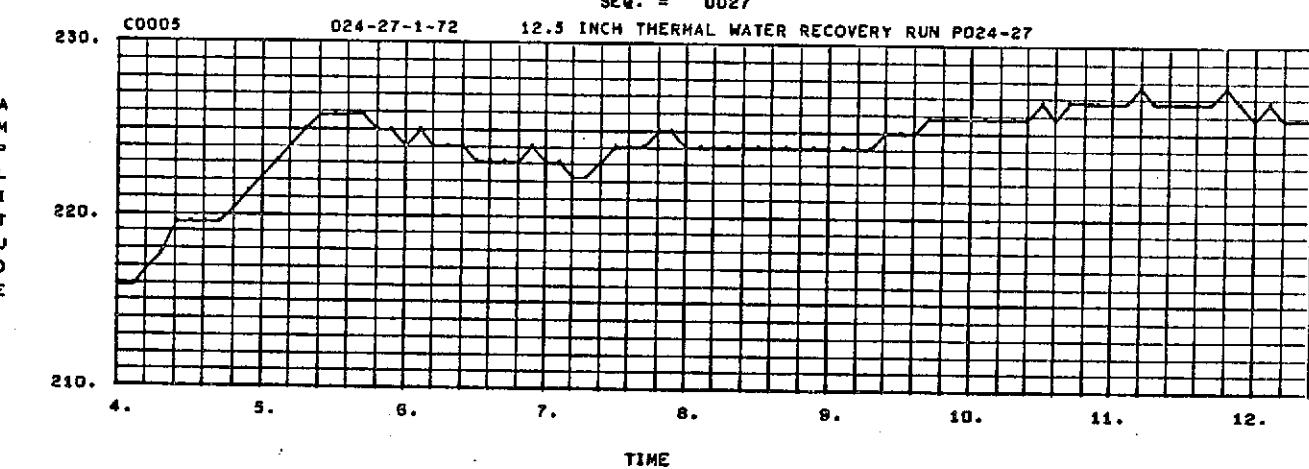
SEQ. = 0027

2

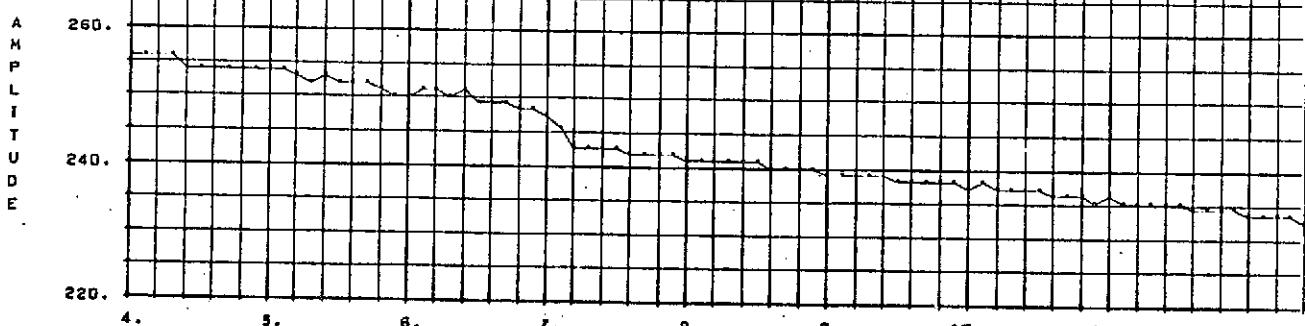


SEQ. = 0027

1

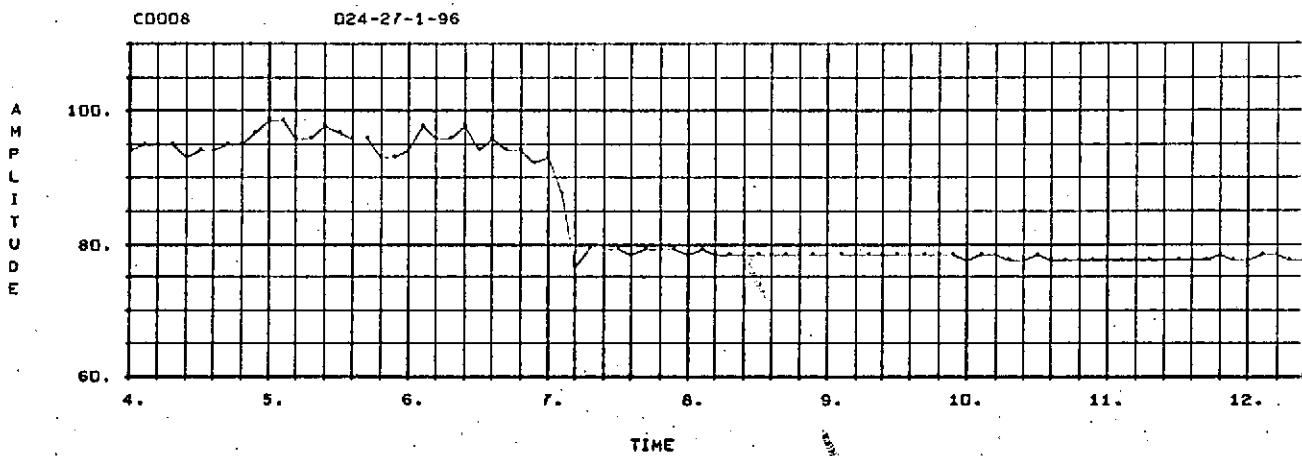
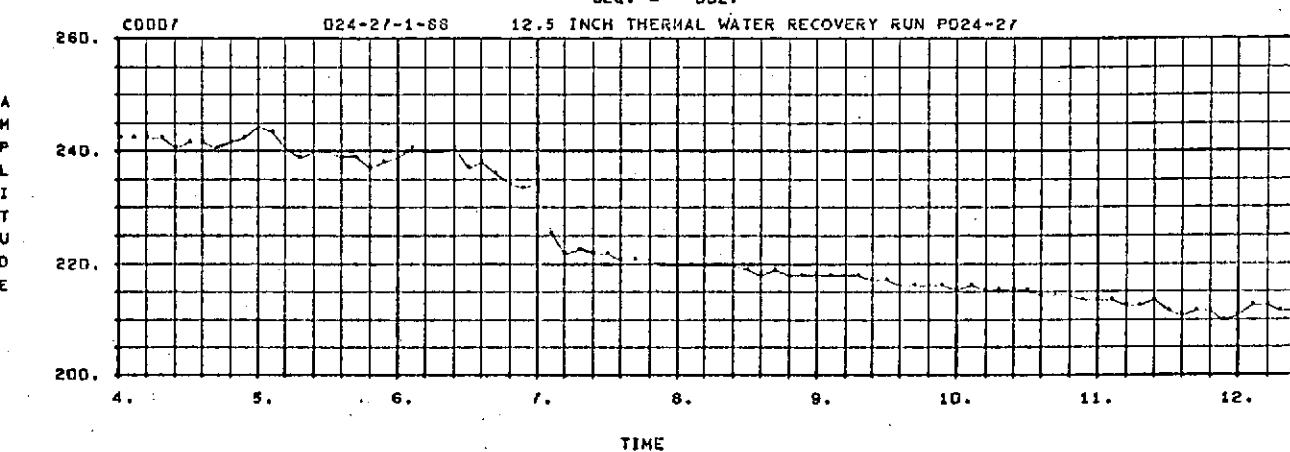


C0006 024-27-1-80



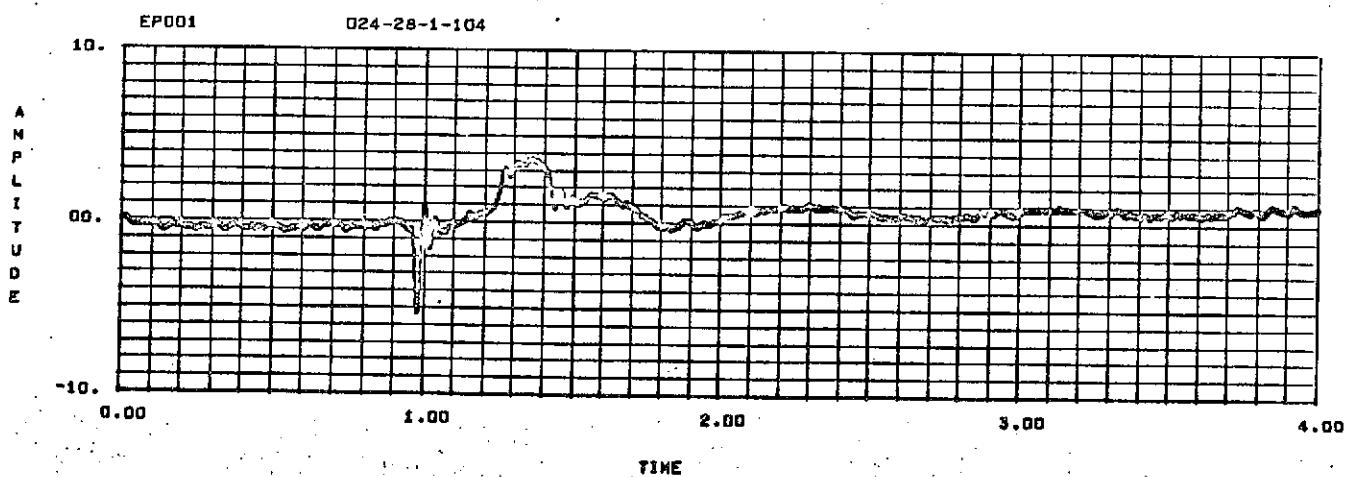
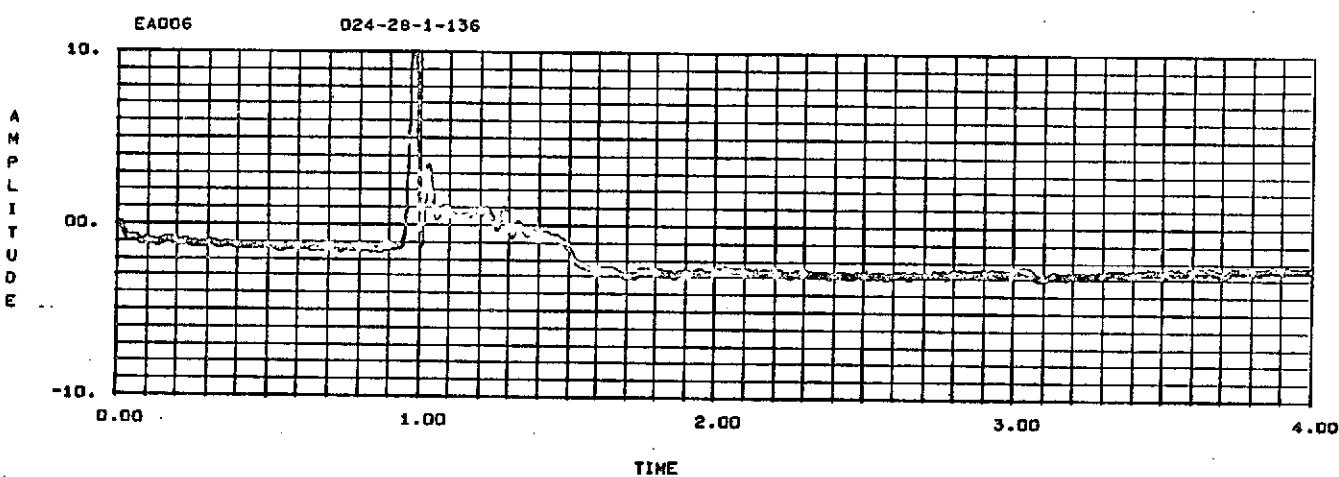
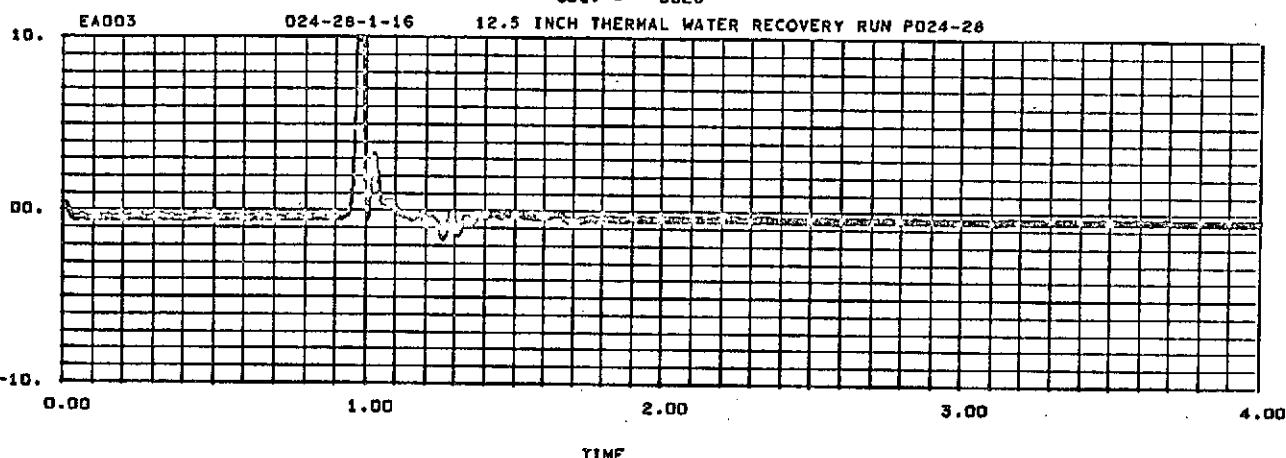
TIME
B-230

SEQ. = 0027



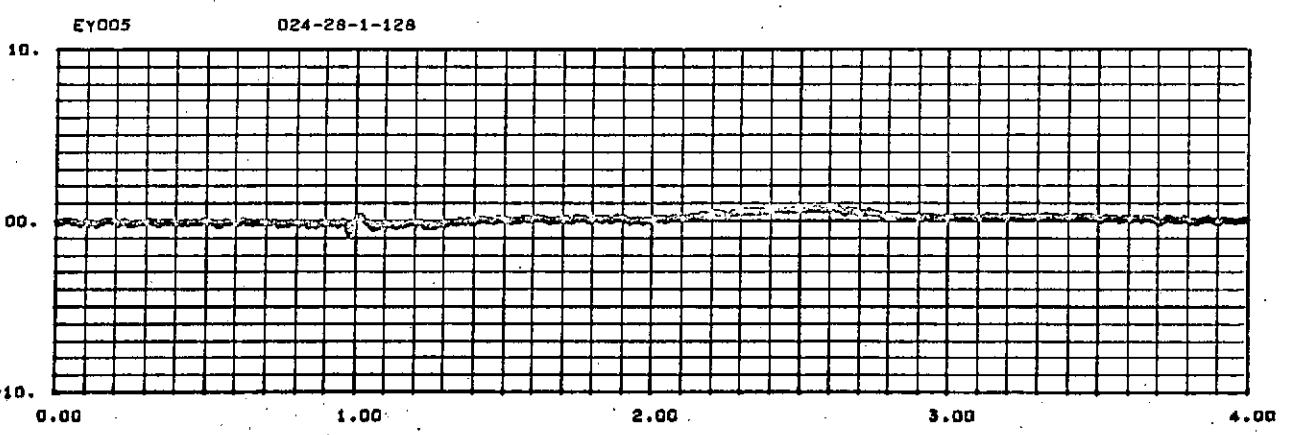
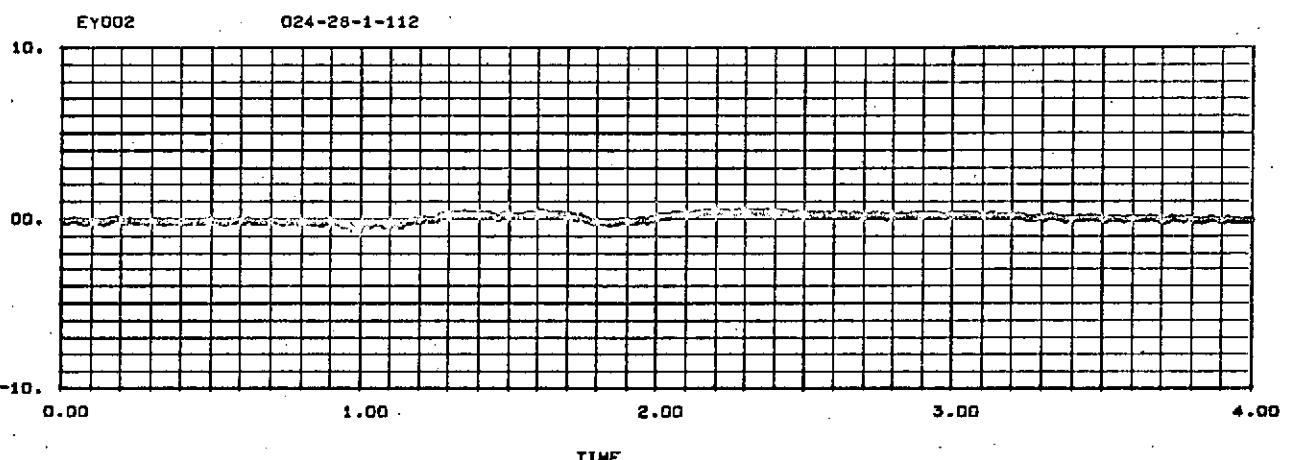
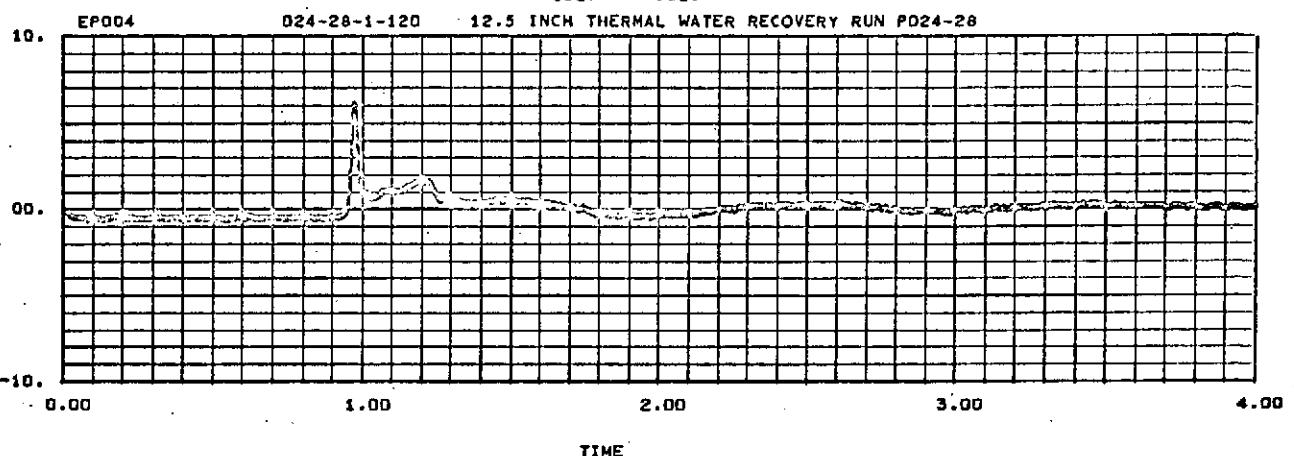
REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

SEQ. = 0028



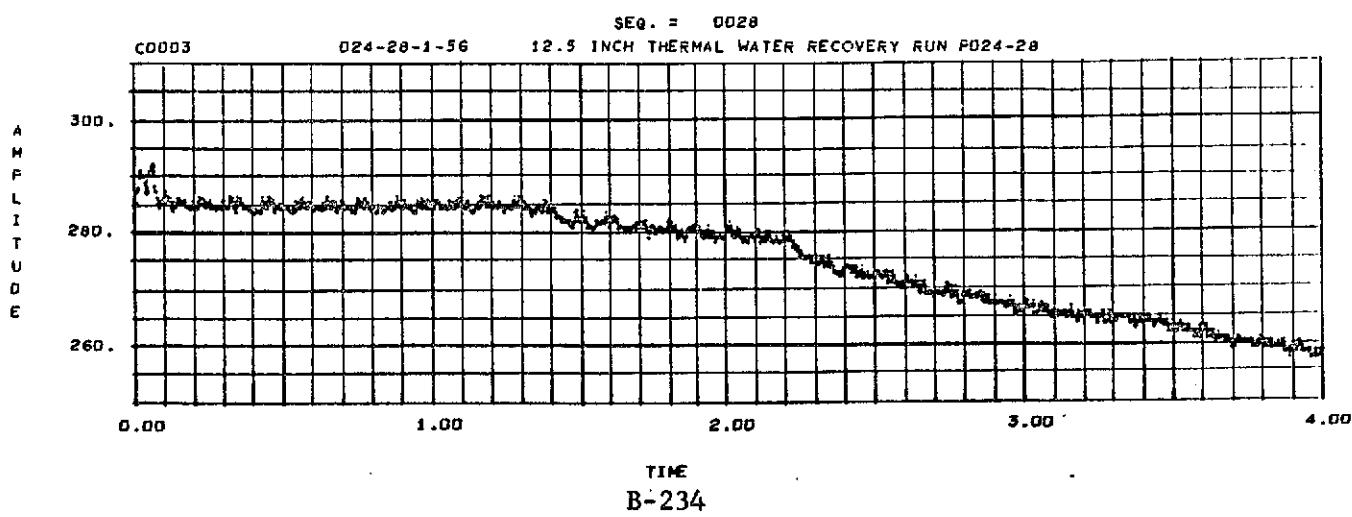
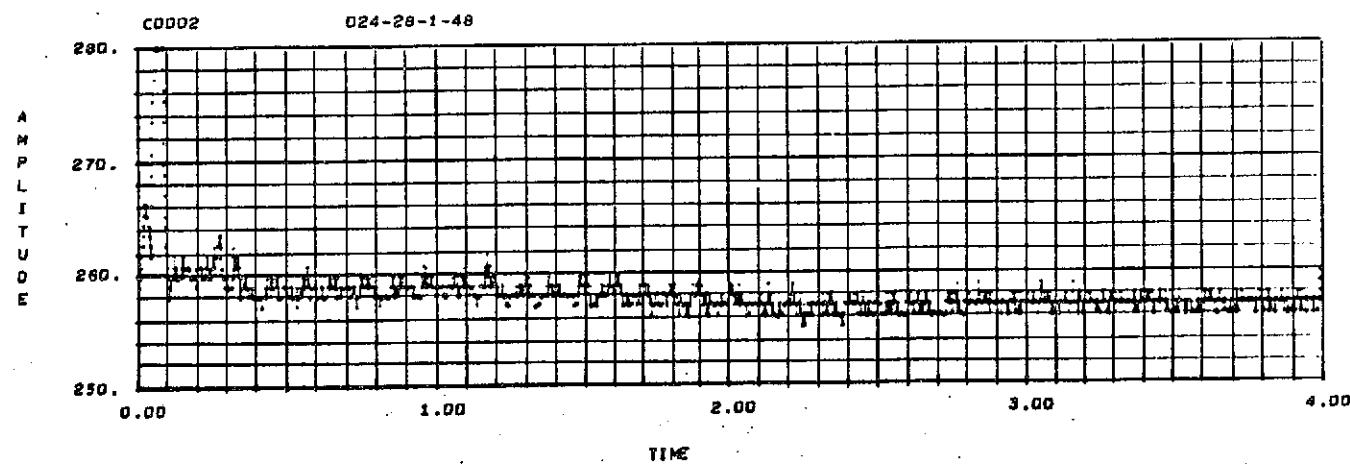
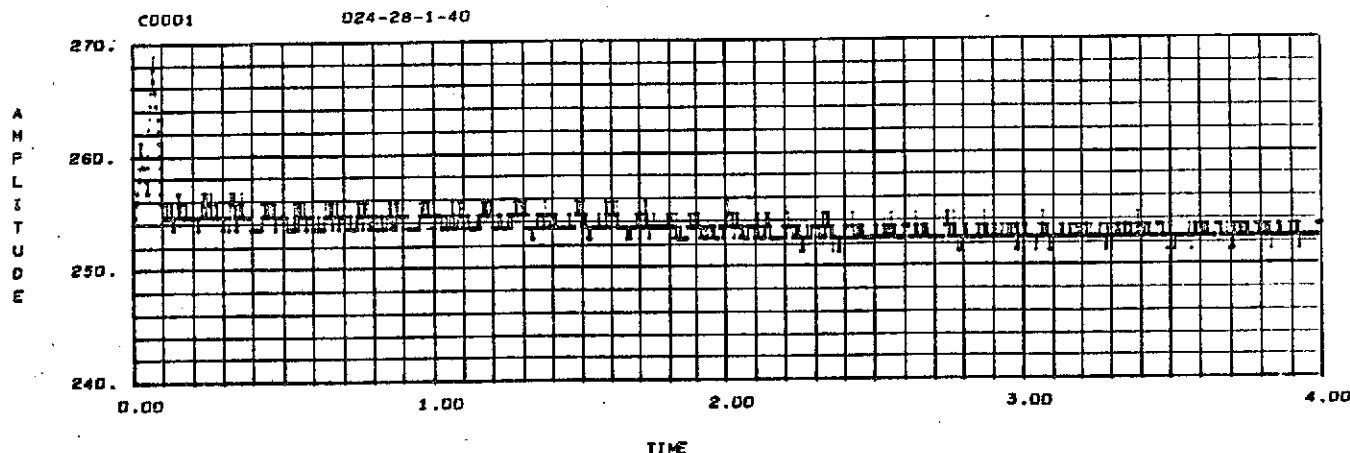
B-232

SEQ. = 0028

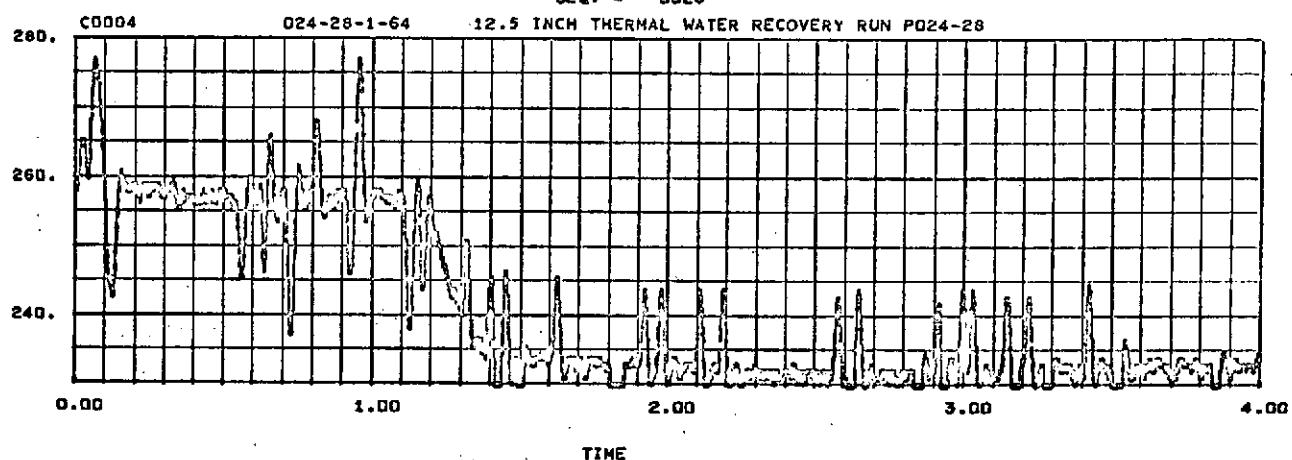


REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

B-233

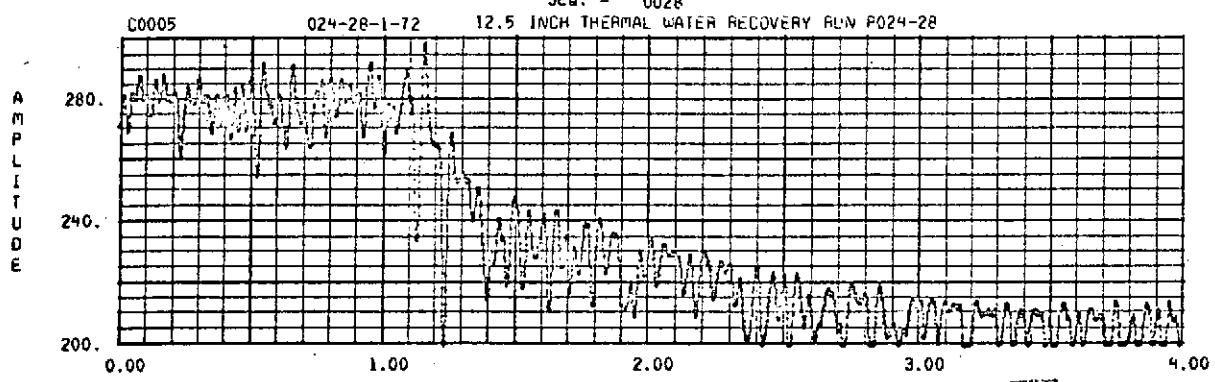


SEQ. = 0028



TIME

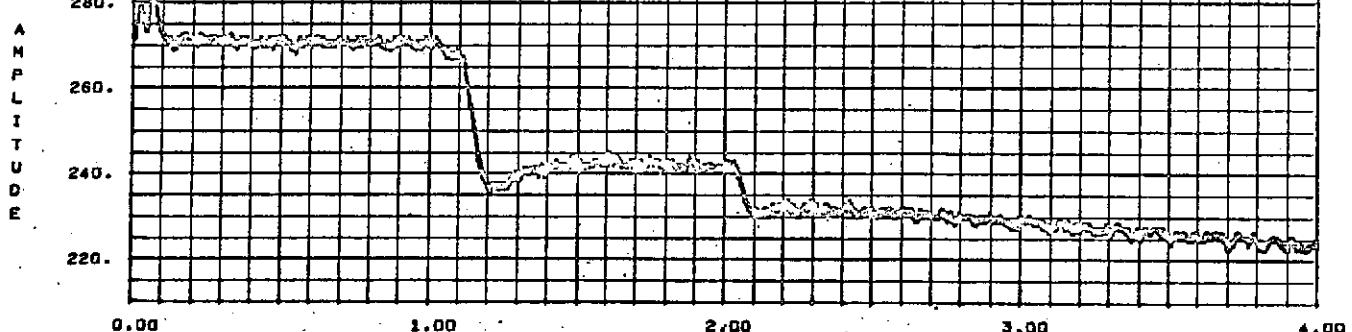
SEQ. = 0028



TIME

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

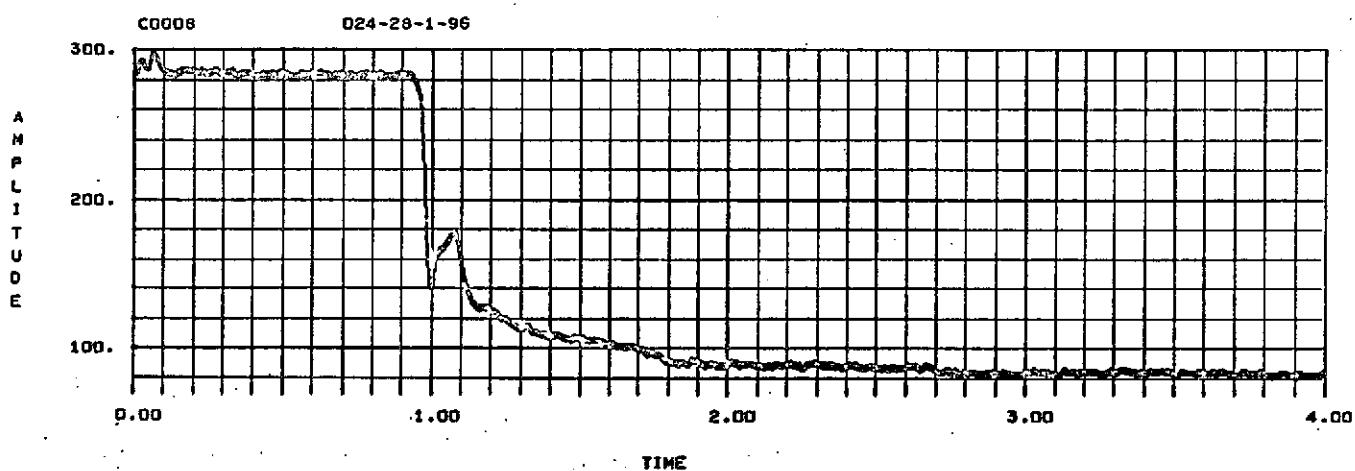
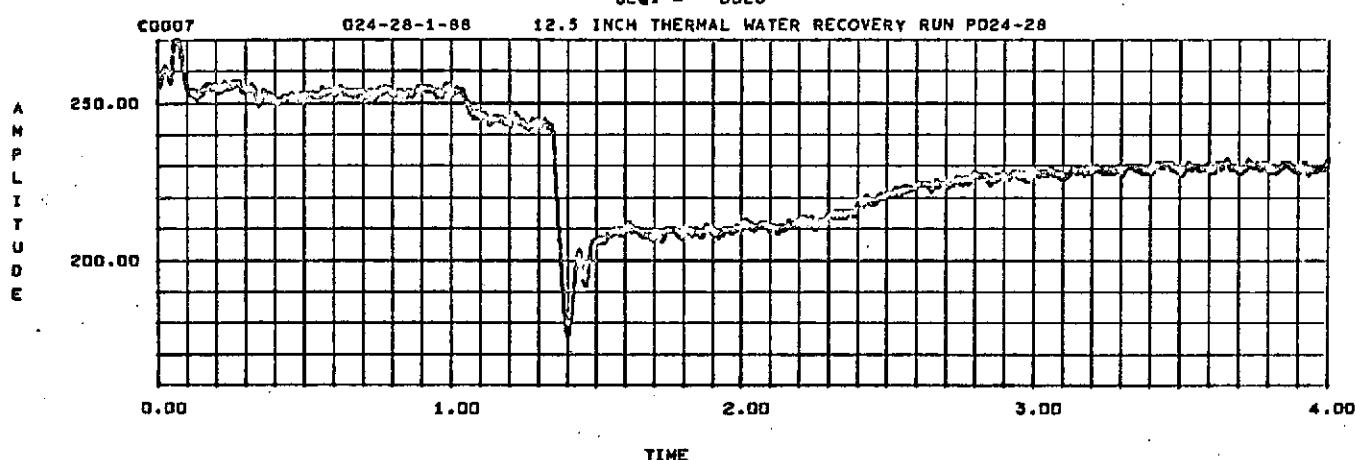
C0006 024-28-1-80

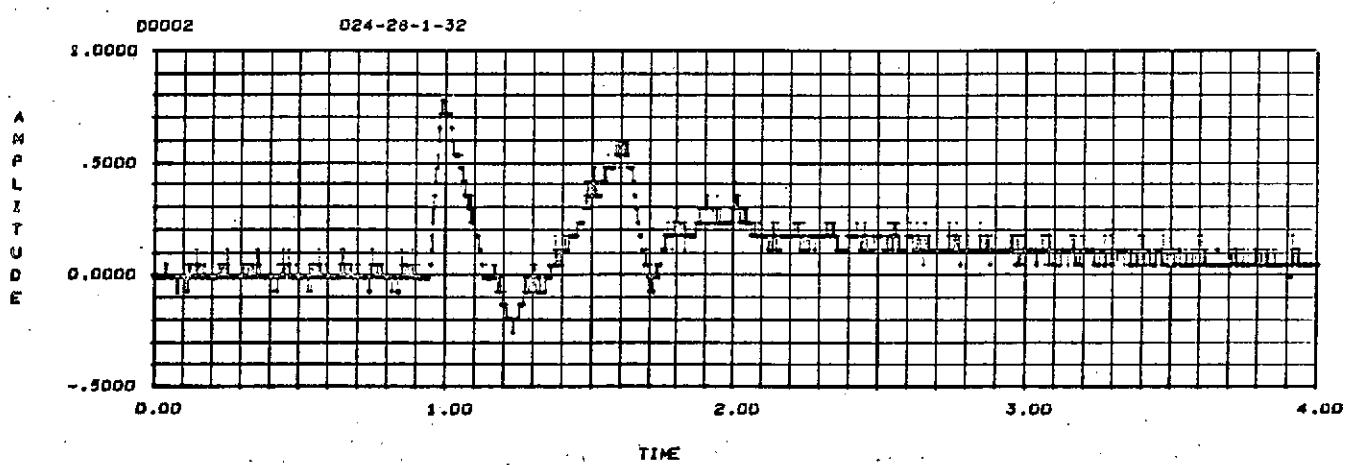
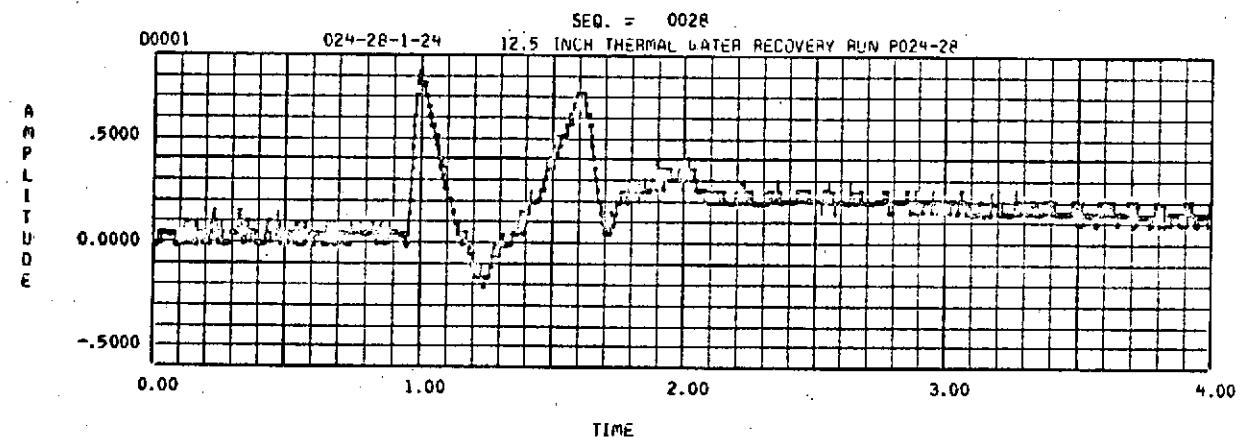


TIME

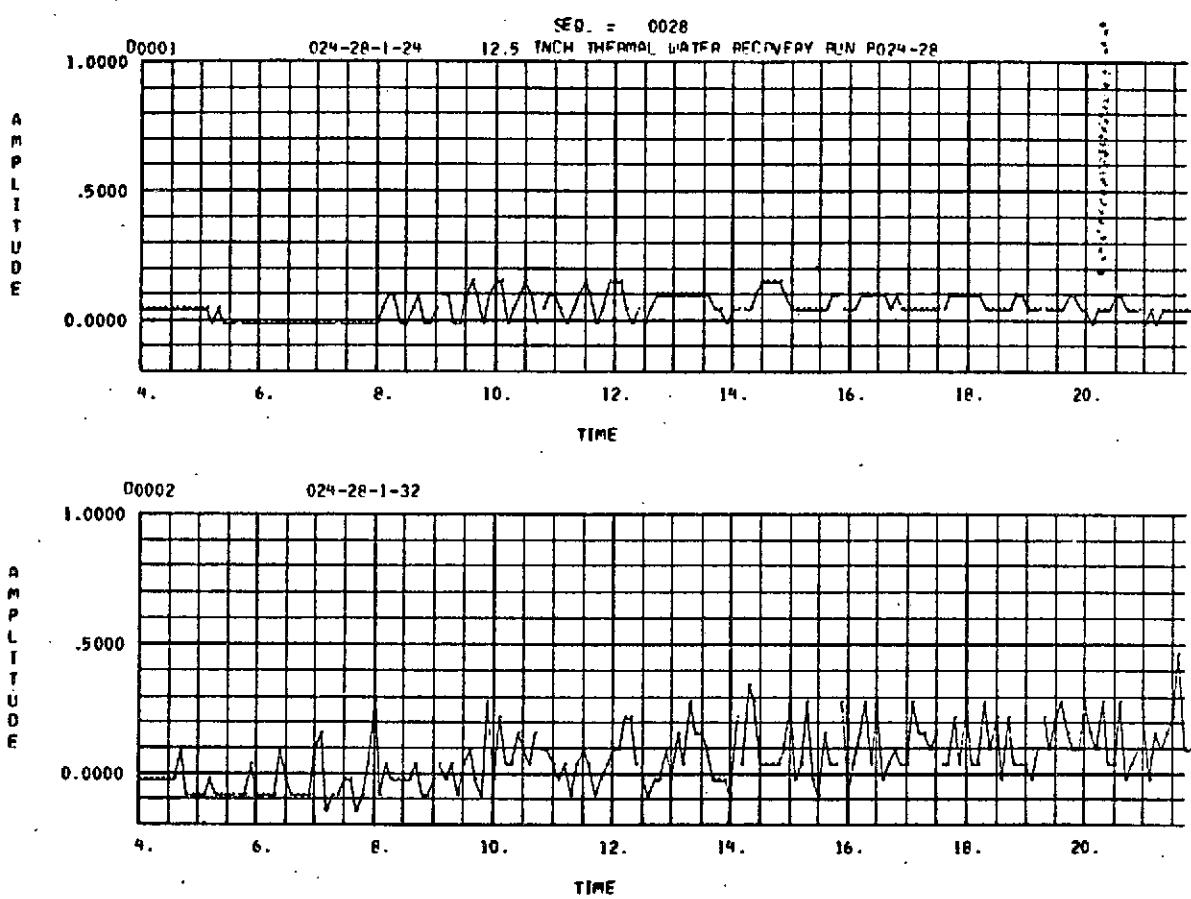
B-235

SEQ. = 0028



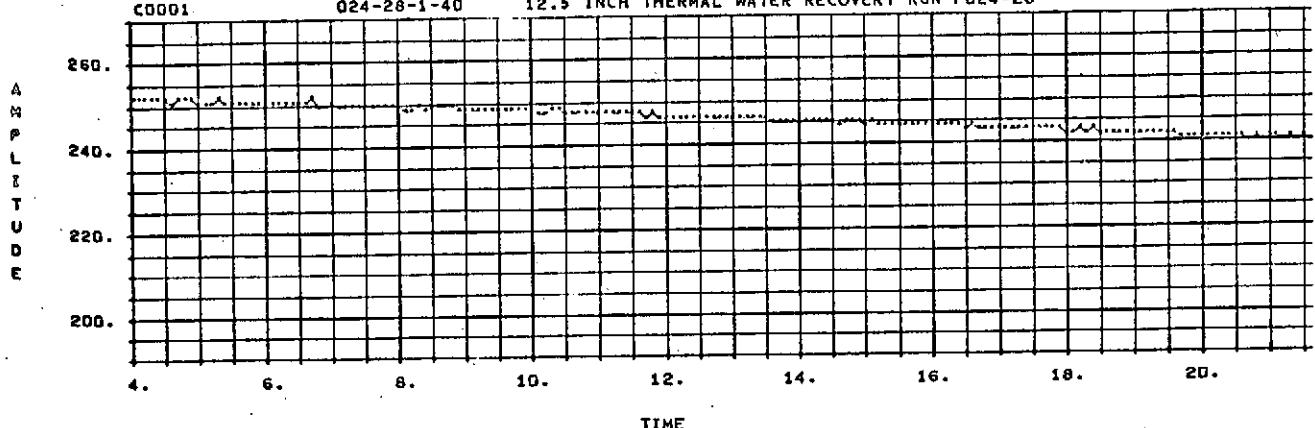


REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

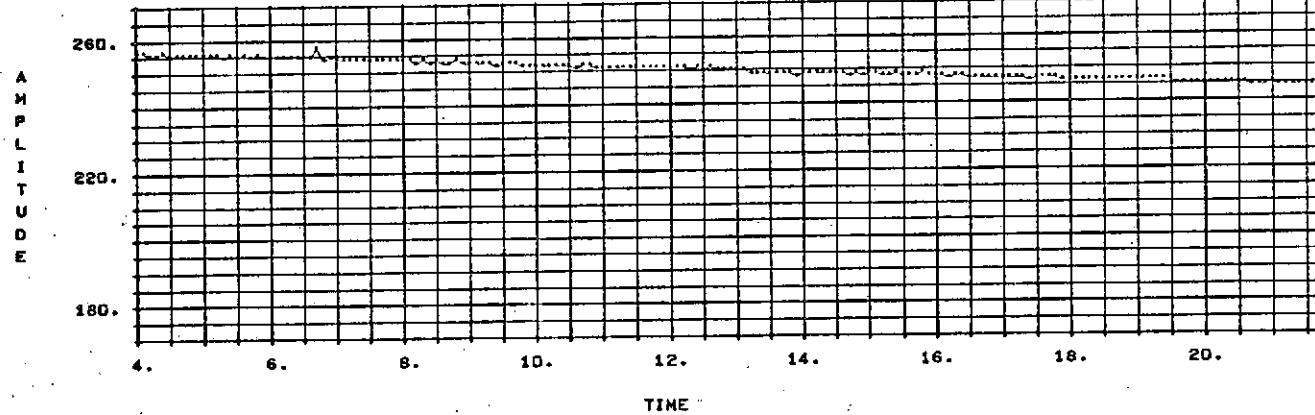


SEQ. = 0028

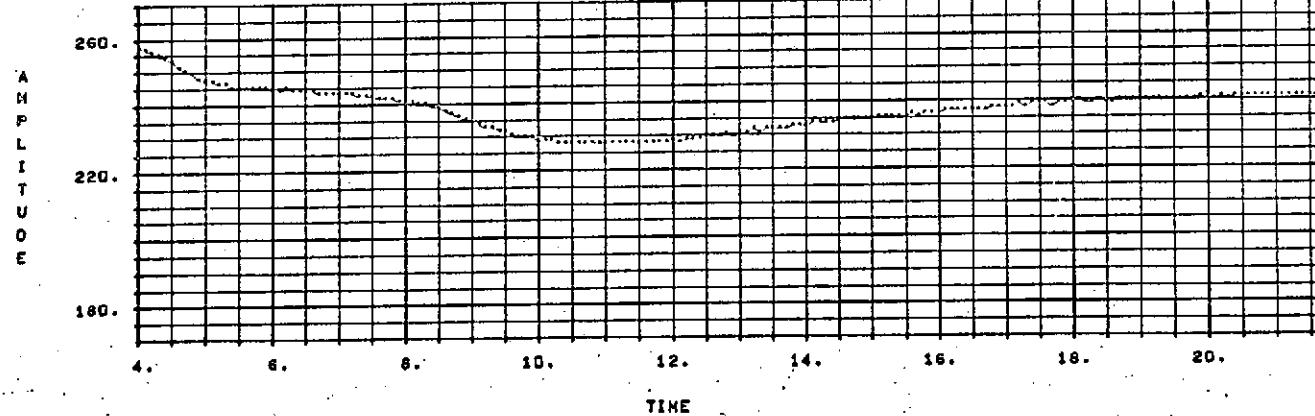
C0001 024-28-1-40 12.5 INCH THERMAL WATER RECOVERY RUN P024-28



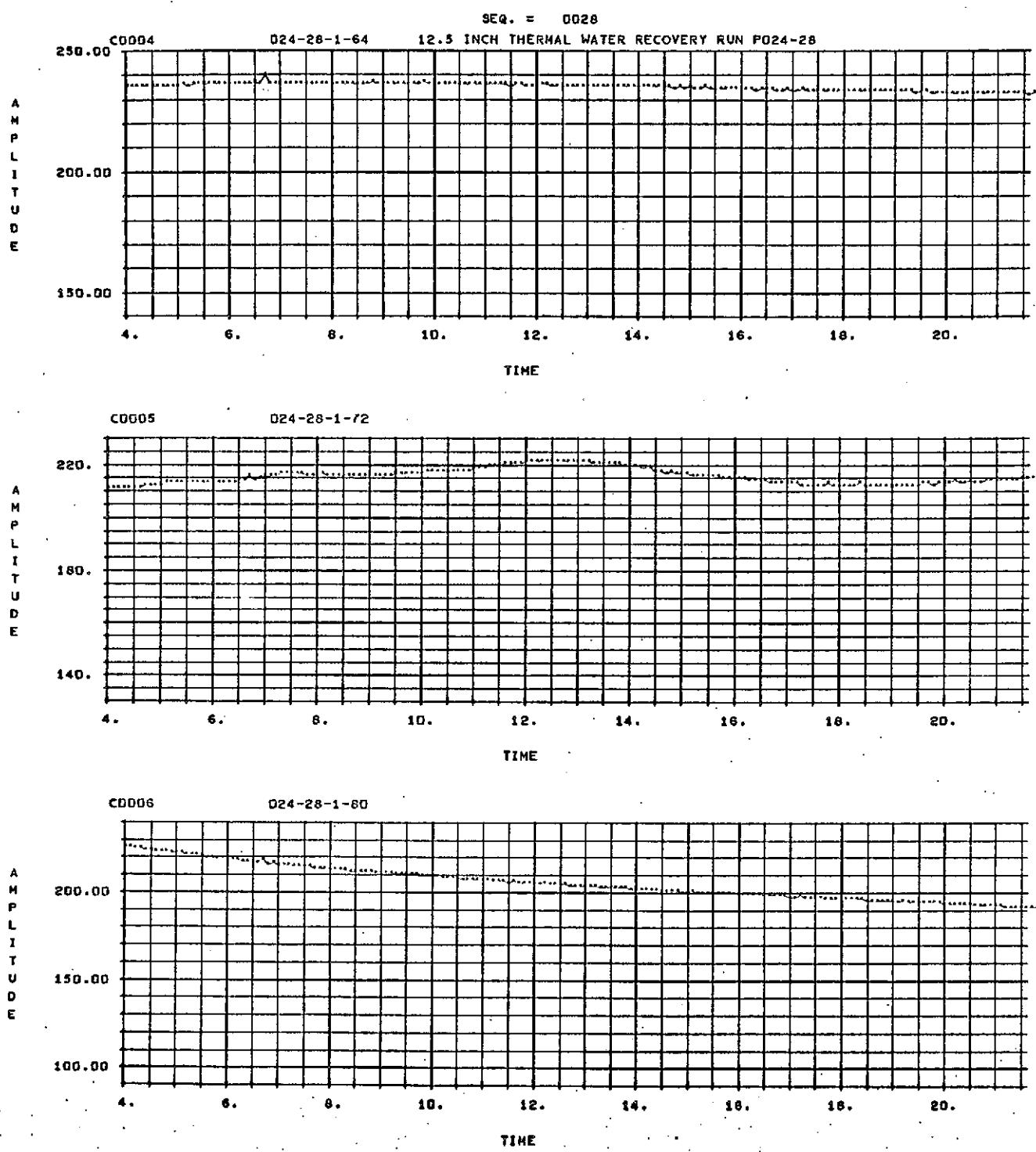
C0002 024-28-1-48

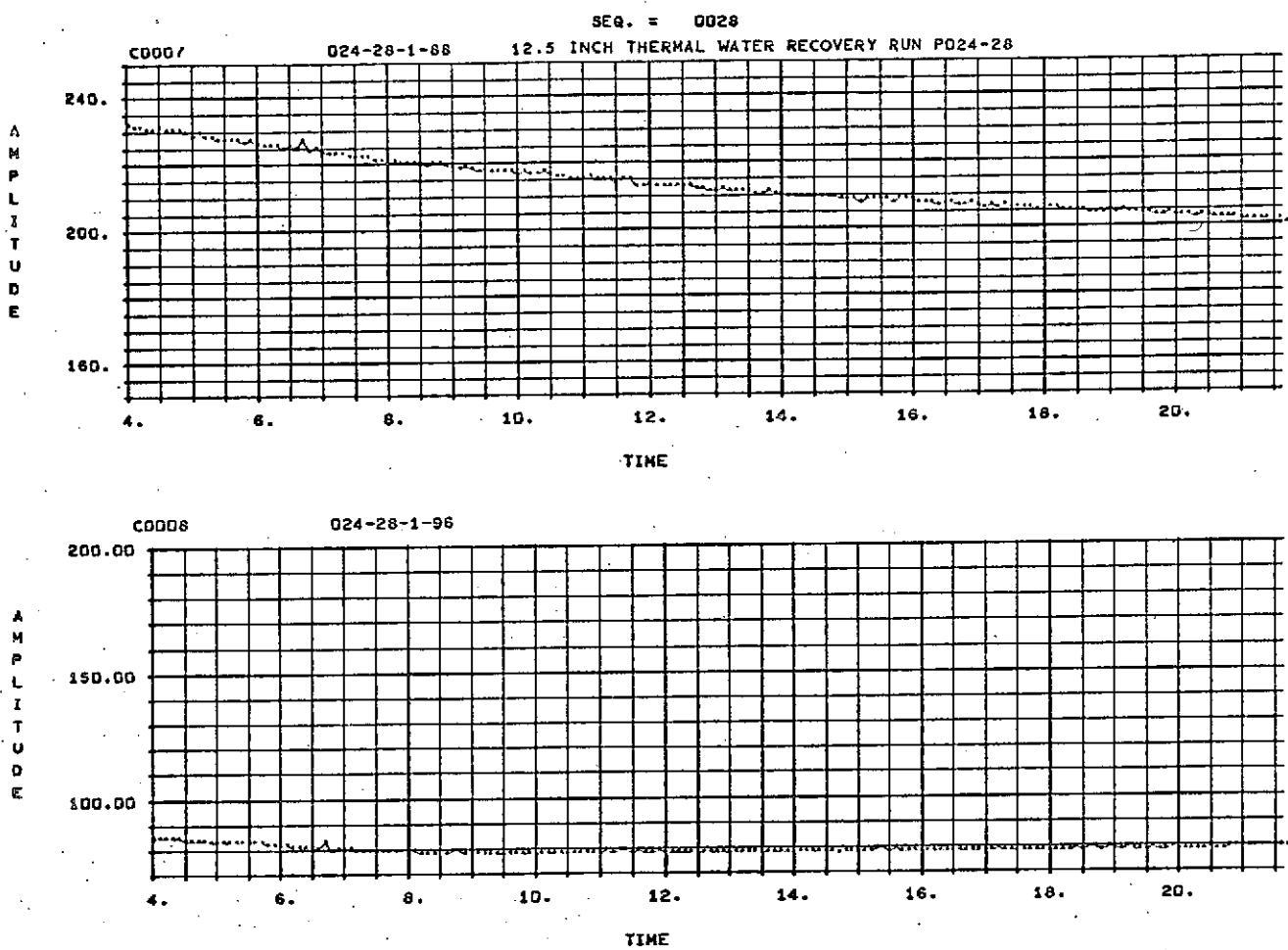


C0003 024-28-1-56



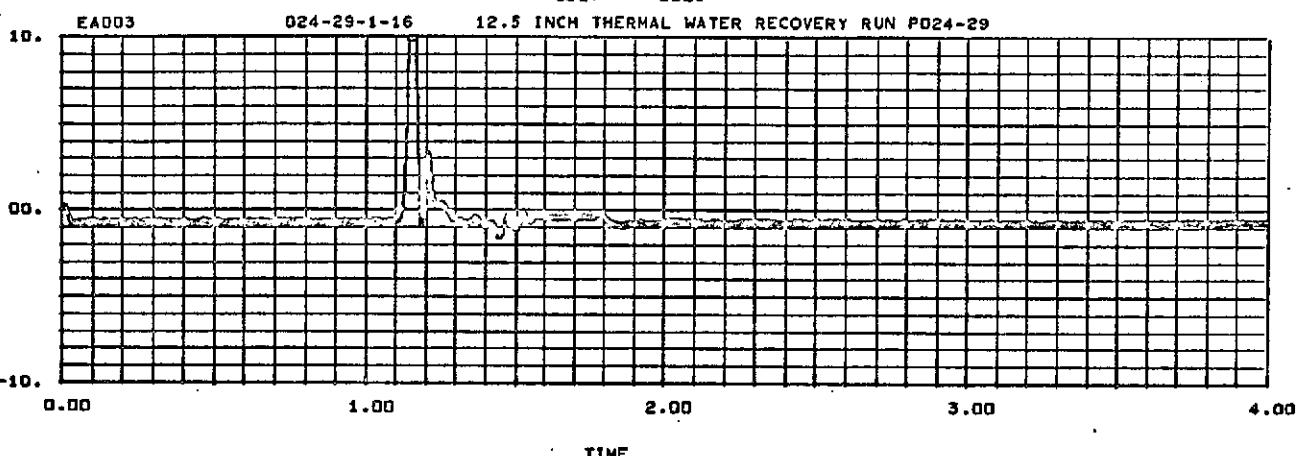
REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR



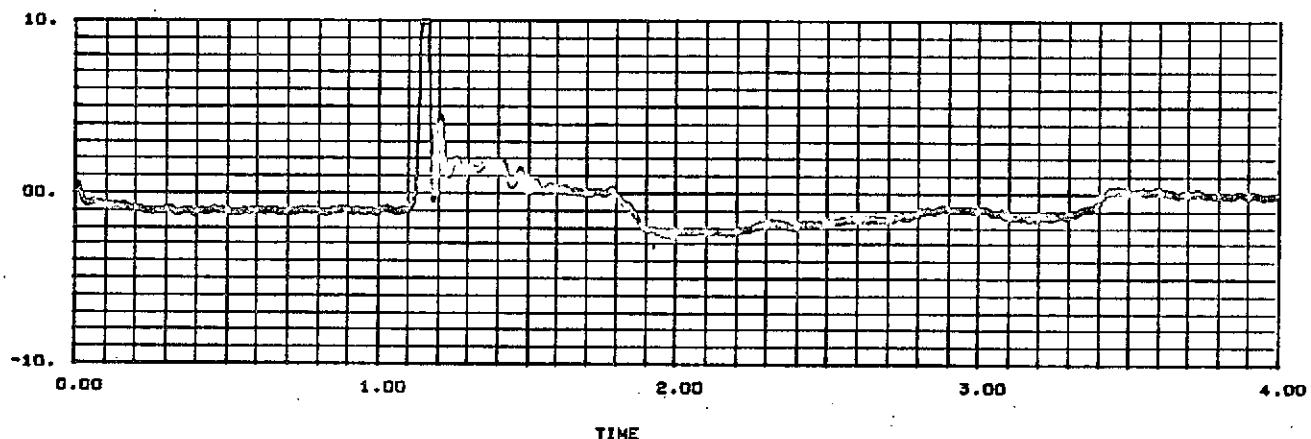


REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

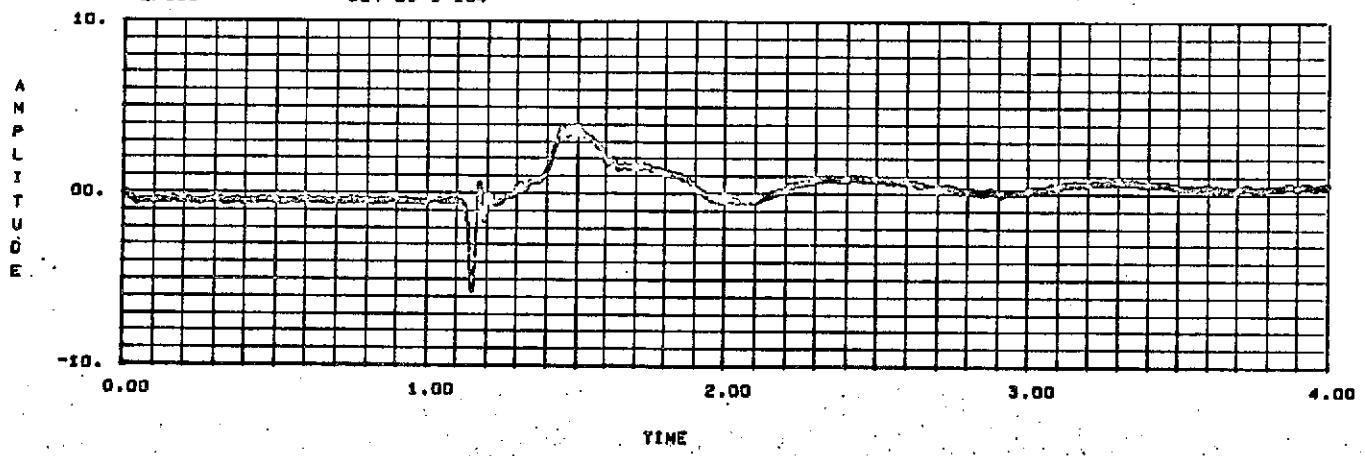
SEQ. = 0029



EA006 024-29-1-136

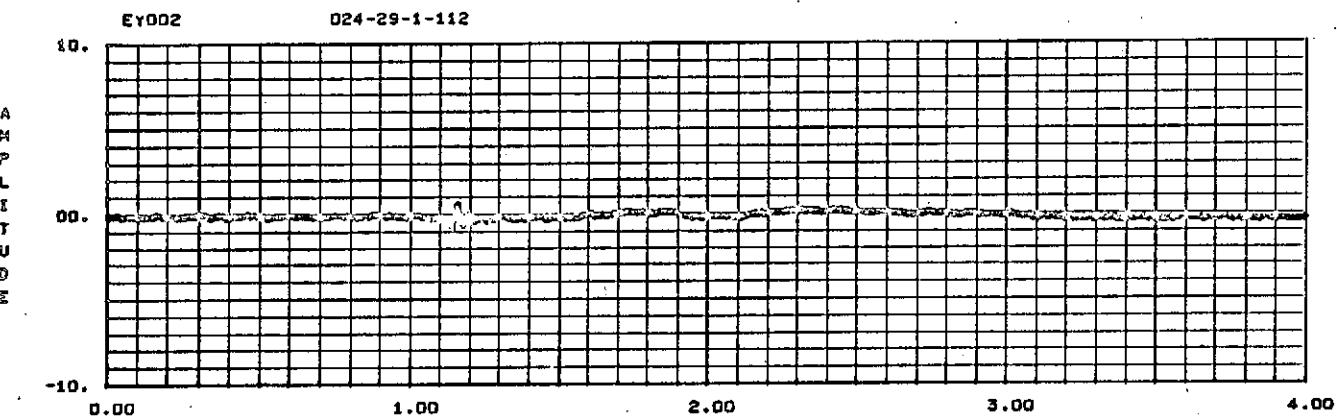
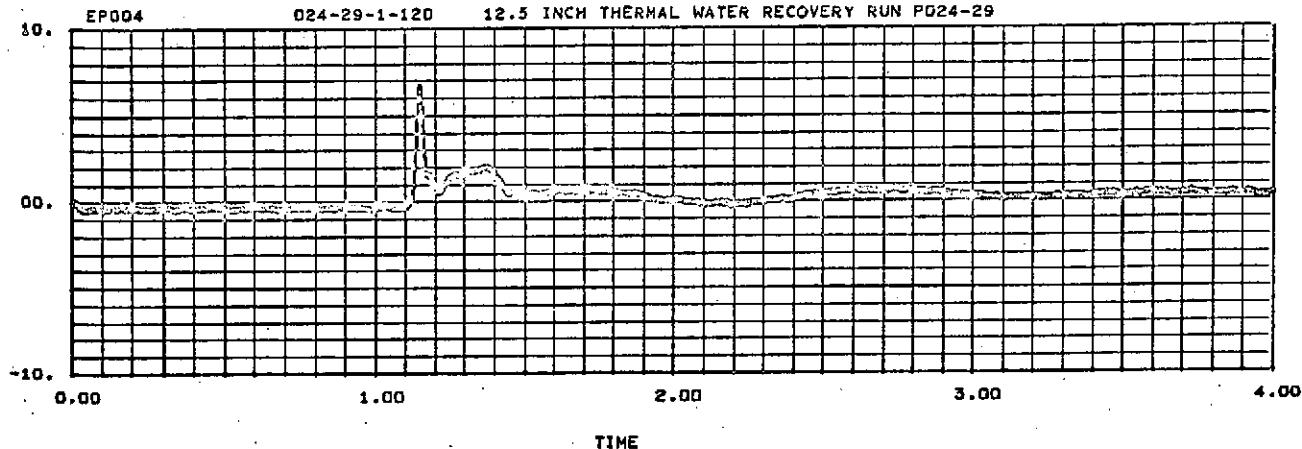


EP001 024-29-1-104

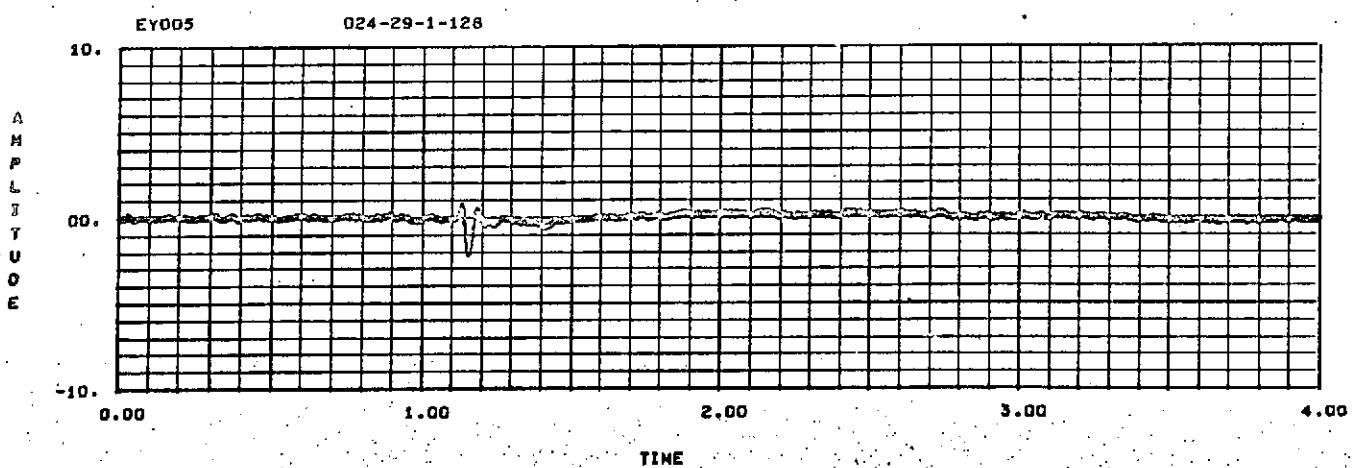


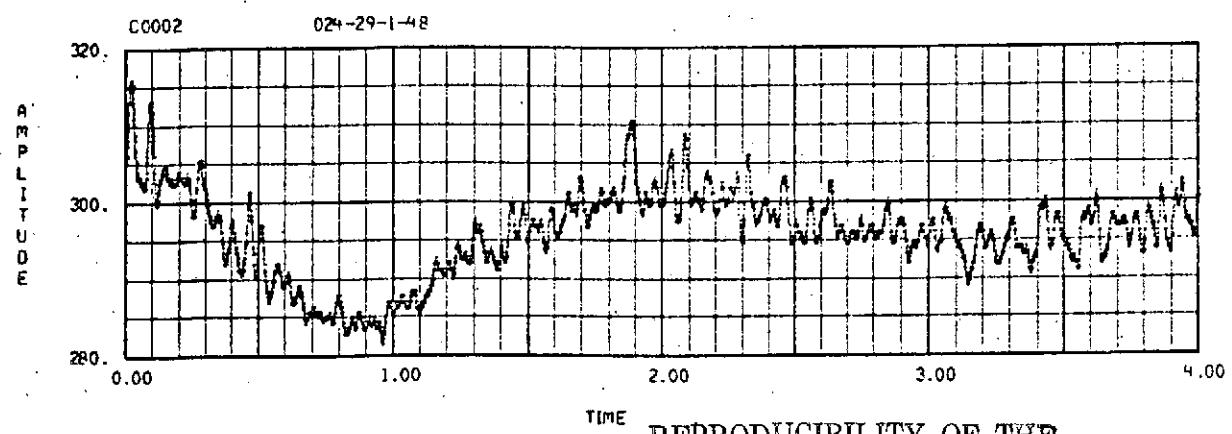
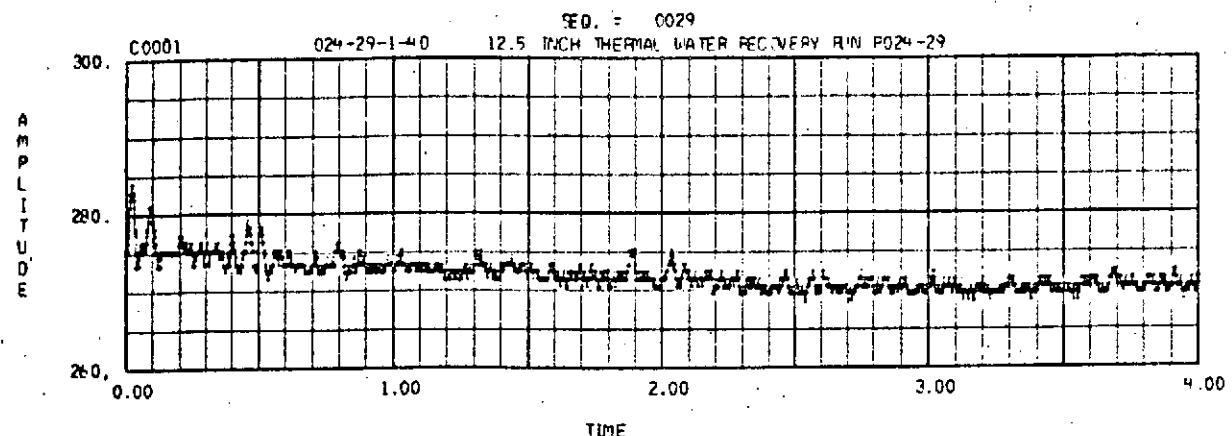
B-242-A

SEQ. = 0029

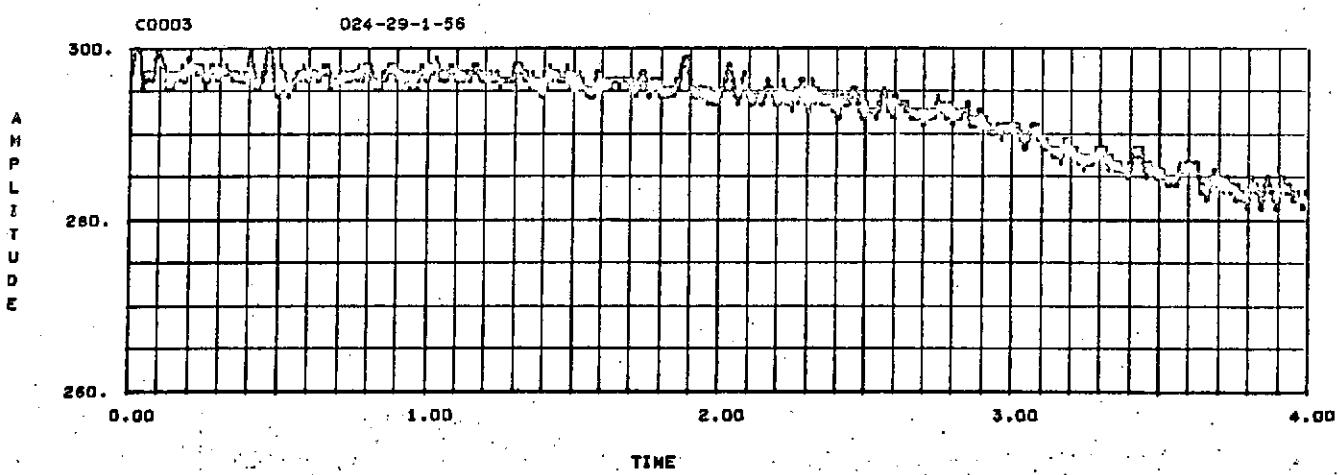


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ORIGINAL PAGE IS POOR





REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR



SEQ. = 0029

C0004

024-29-1-64

12.5 INCH THERMAL WATER RECOVERY RUN P024-29

AMPLITUDE

260.
240.
220.

0.00

1.00

2.00

3.00

4.00

TIME

C0005

024-29-1-72

AMPLITUDE

300.
260.
220.

0.00

1.00

2.00

3.00

4.00

TIME

C0006

024-29-1-80

AMPLITUDE

280.
240.
200.

0.00

1.00

2.00

3.00

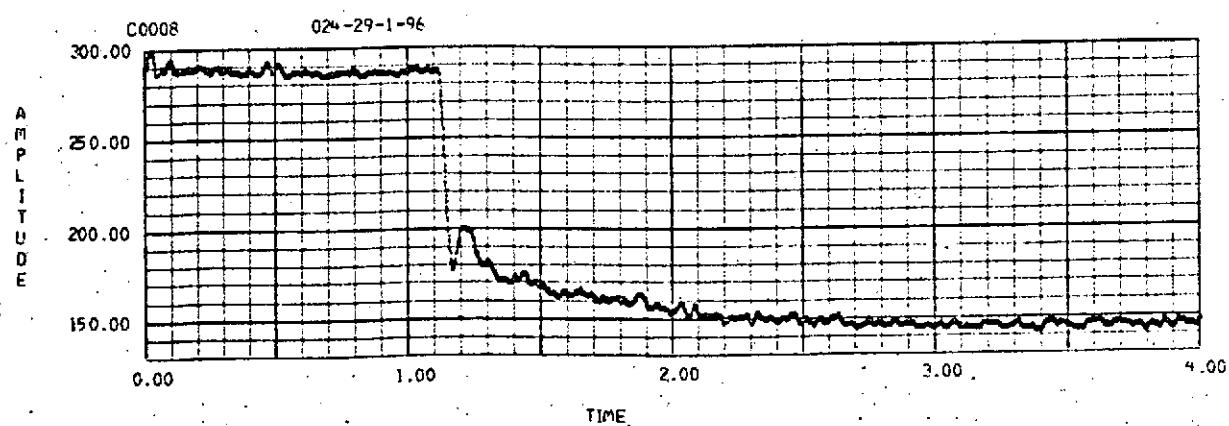
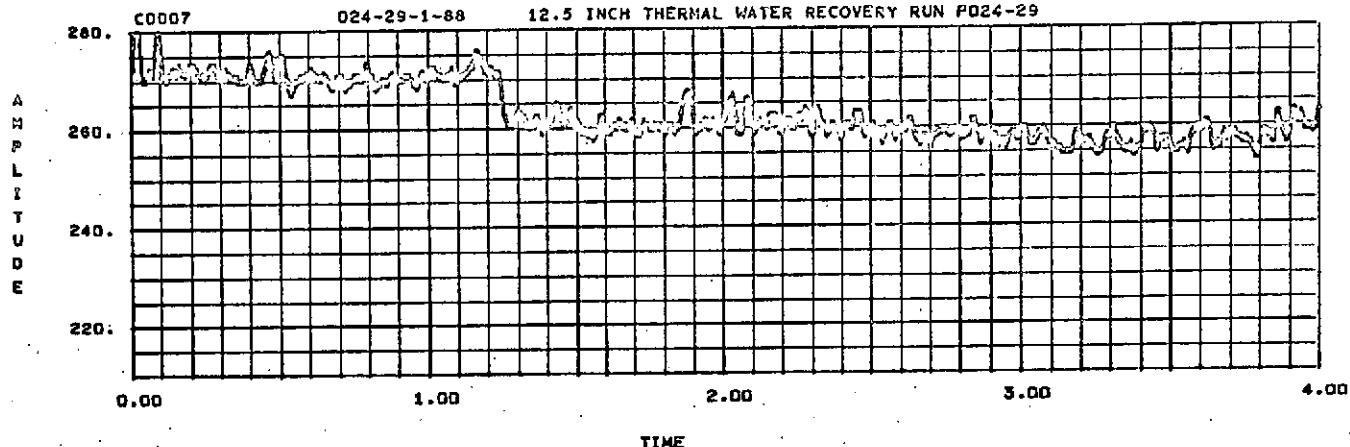
4.00

TIME

B-244

SEE. = 0029

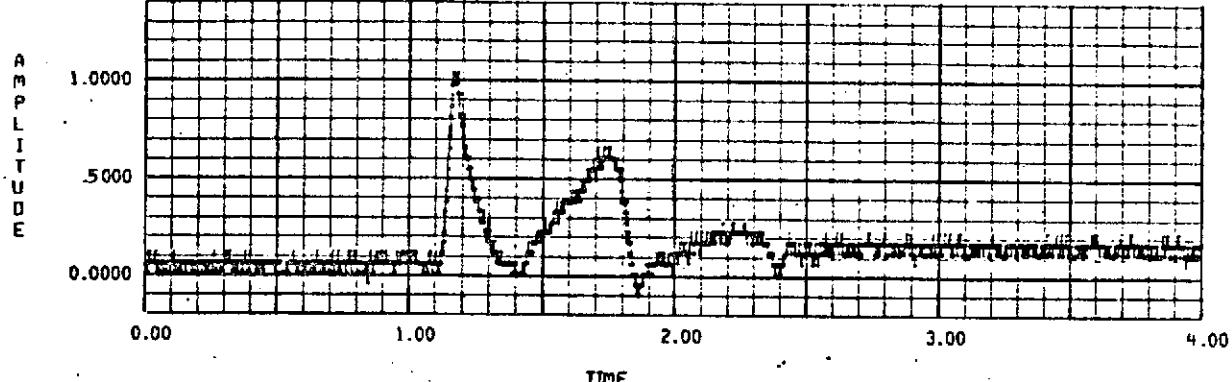
024-29-1-88 12.5 INCH THERMAL WATER RECOVERY RUN F024-29



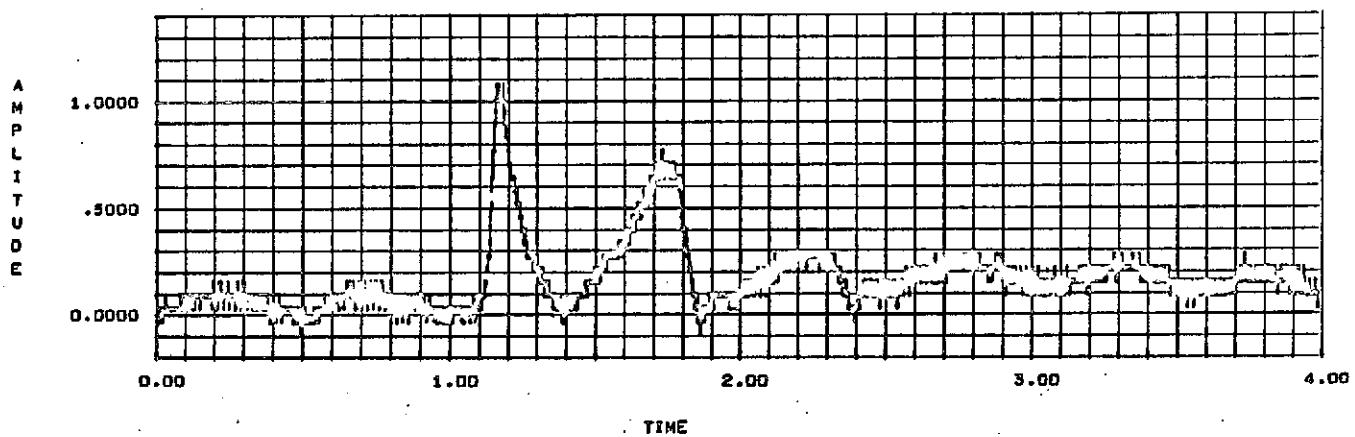
REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

SEQ. = 0029
D0001 024-29-1-24 12.5 INCH THERMAL WATER RECOVERY RUN P024-29

3

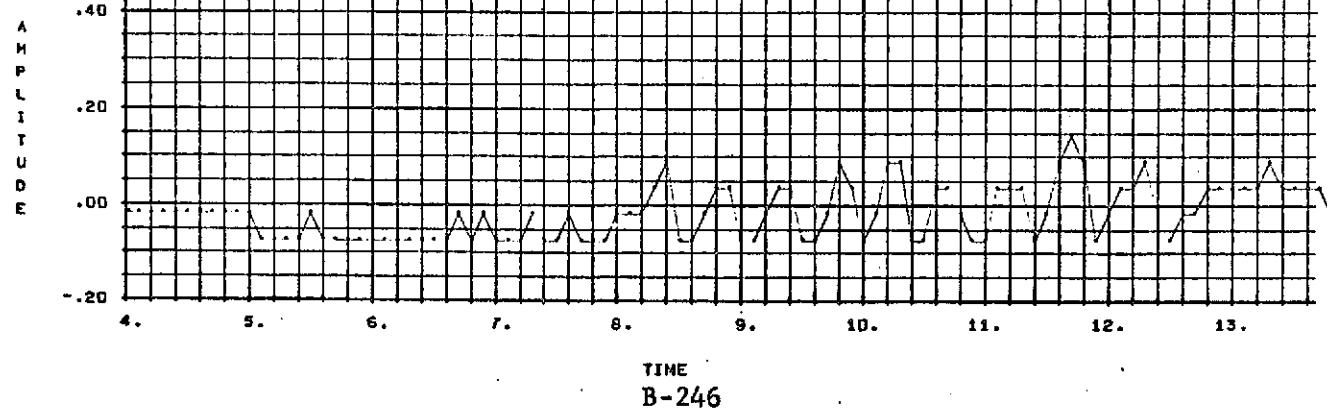


D0002 024-29-1-32



SEQ. = 0029
D0001 024-29-1-24 12.5 INCH THERMAL WATER RECOVERY RUN P024-29

5

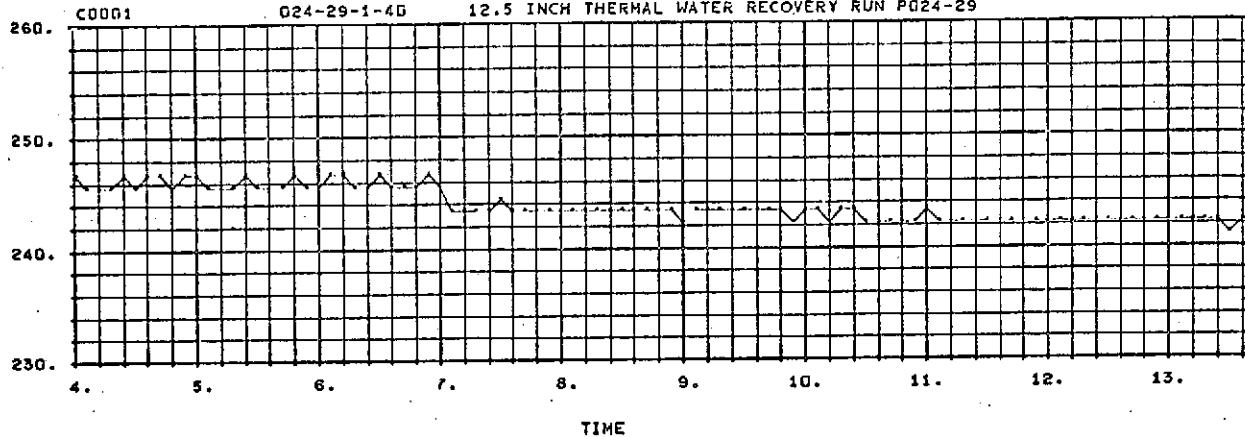


TIME
B-246

----- 024-29-1-24 -----

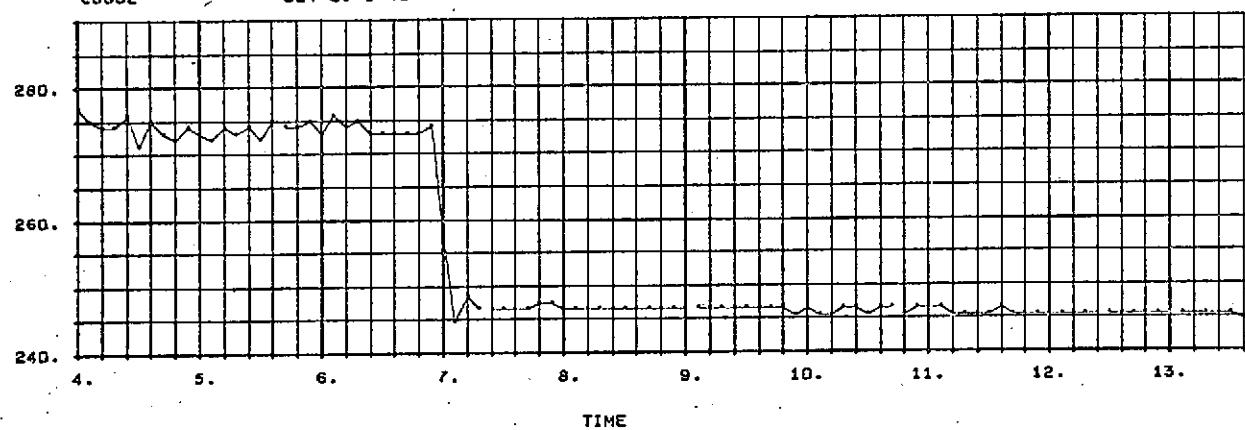
SEQ. = 0029

C0001 024-29-1-4D 12.5 INCH THERMAL WATER RECOVERY RUN P024-29

A
M
P
L
I
T
U
D
E

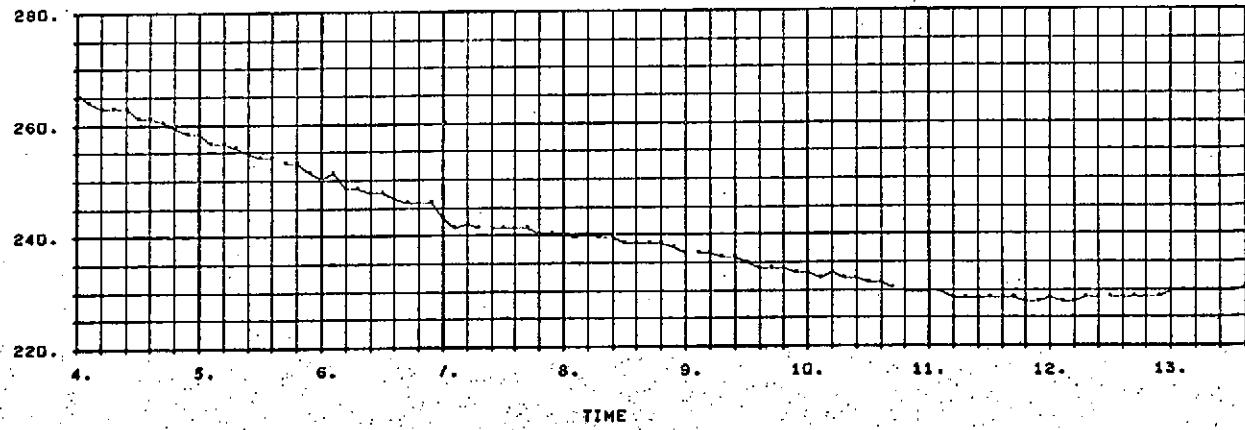
C0002

024-29-1-48

A
M
P
L
I
T
U
D
E

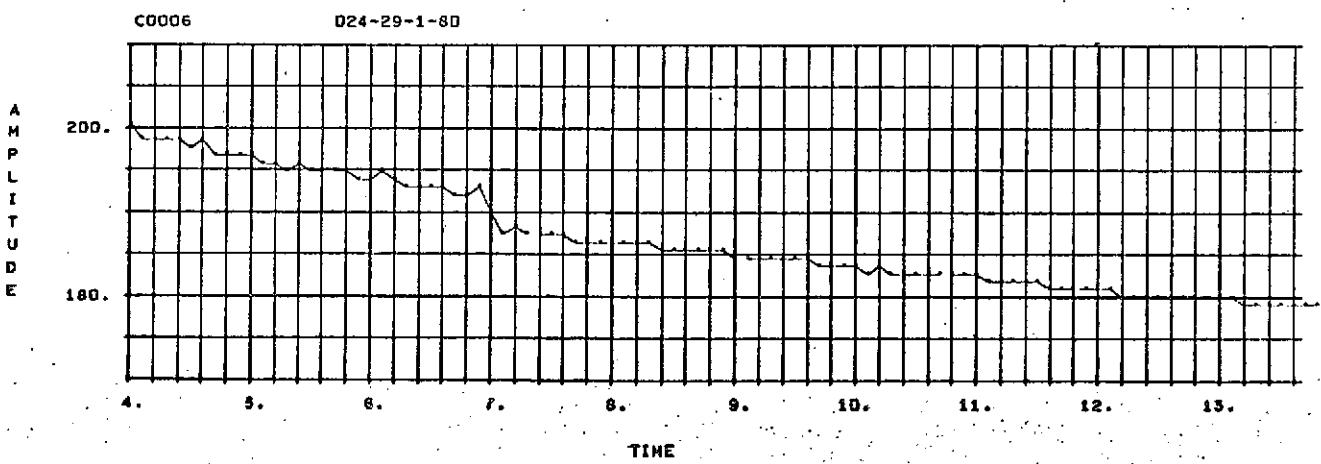
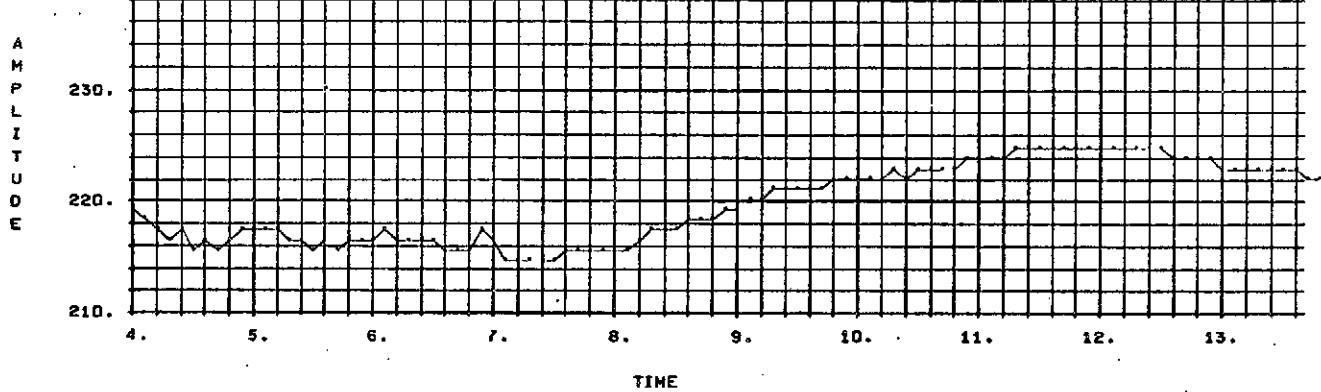
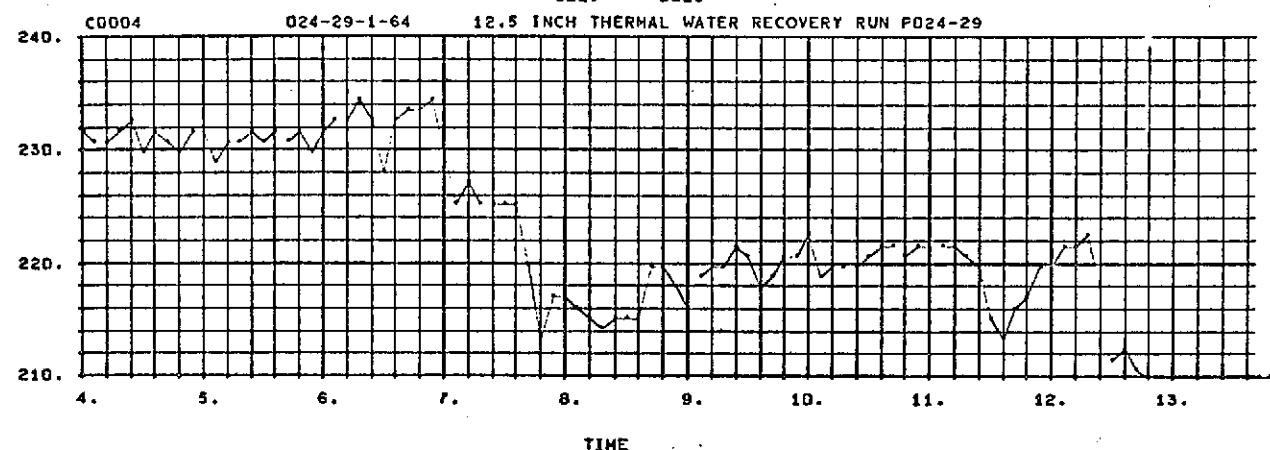
C0003

024-29-1-56

A
M
P
L
I
T
U
D
E

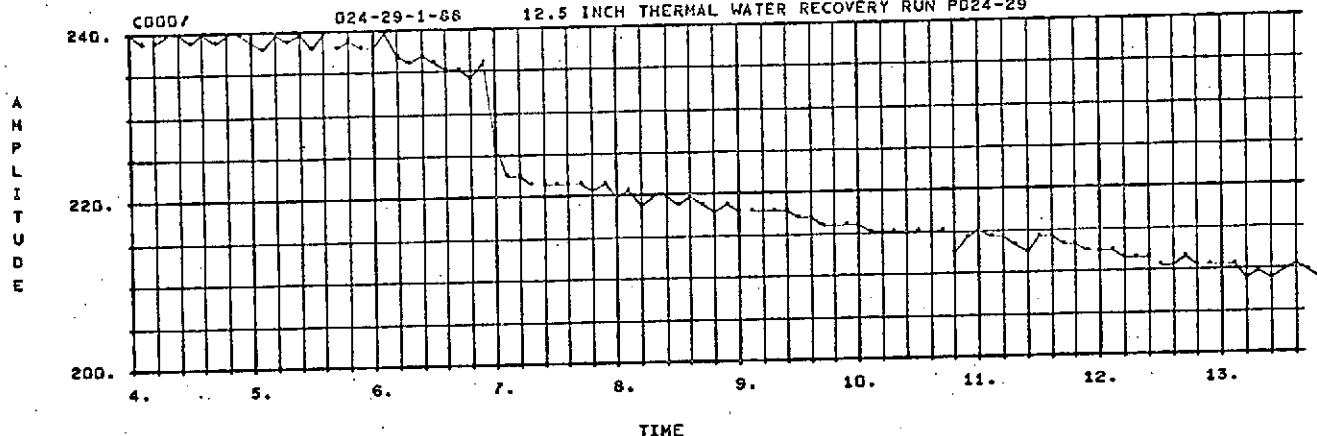
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SEQ. = 0029

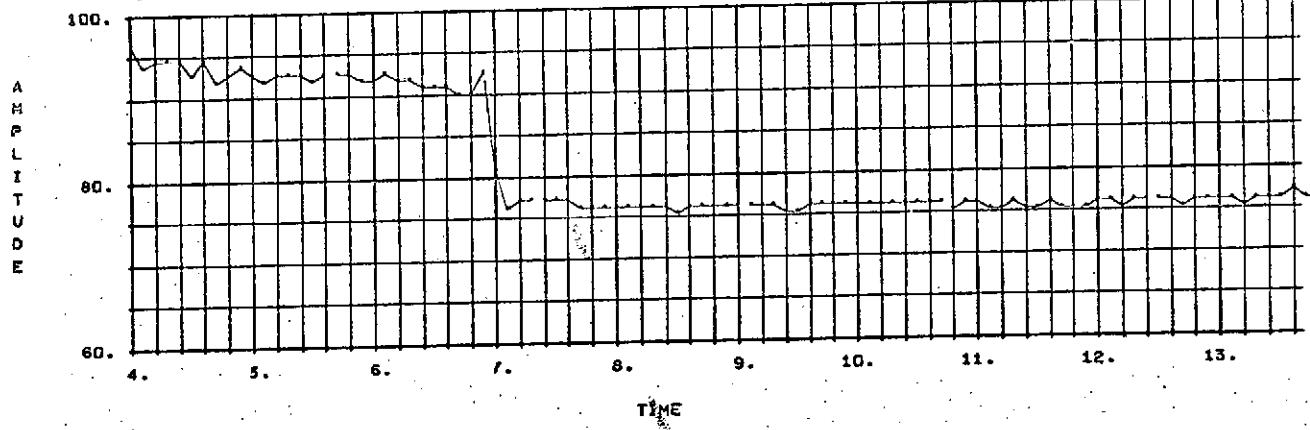


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024-29-1-88 12.5 INCH THERMAL WATER RECOVERY RUN PD24-29



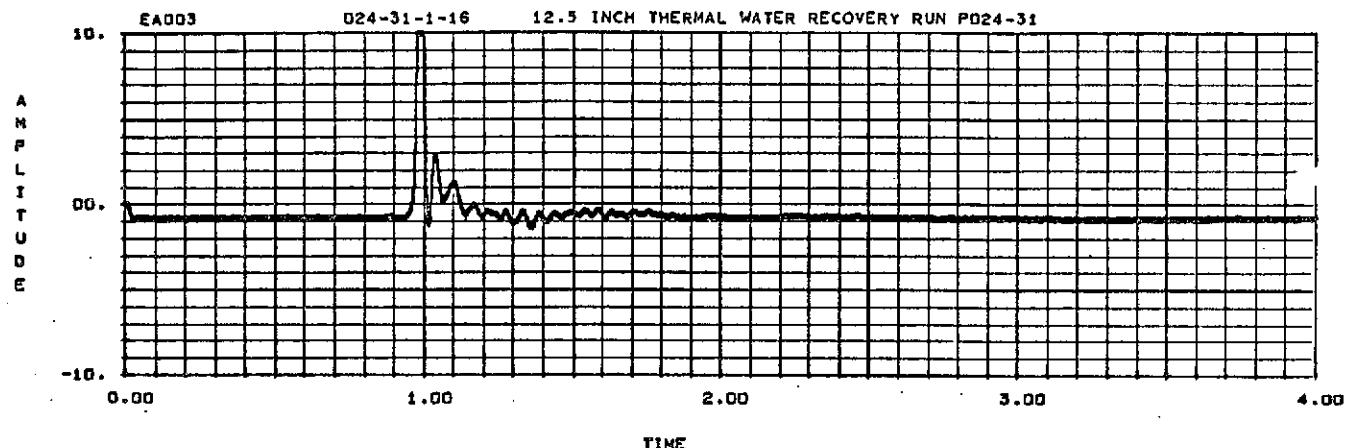
C0005 024-29-1-96



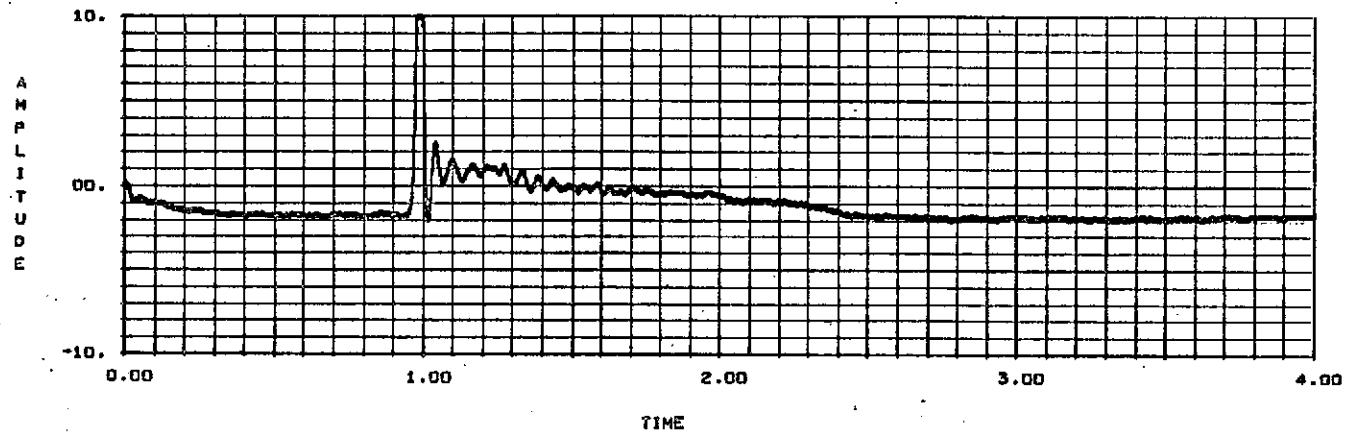
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SEQ. = 0031

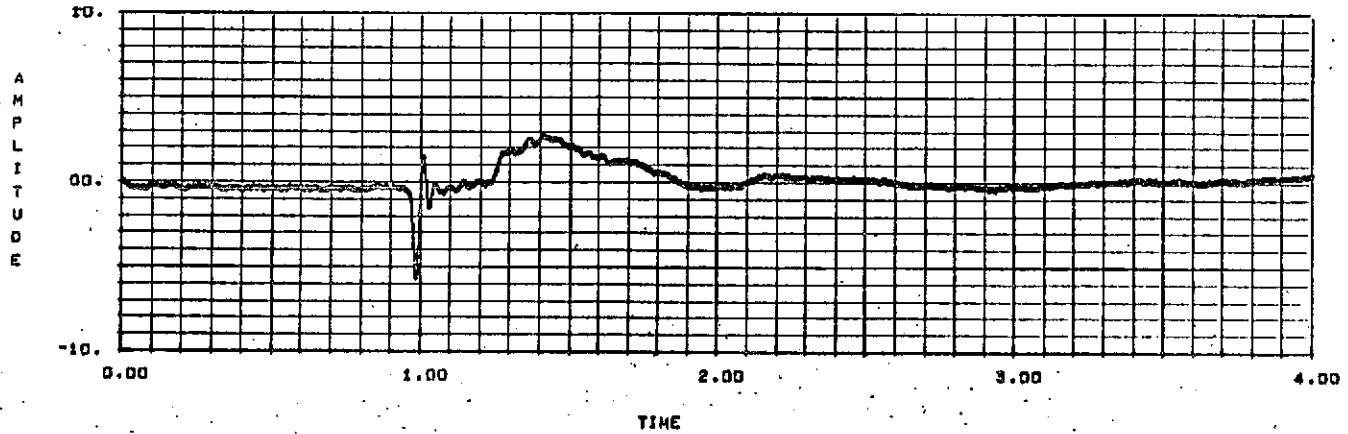
024-31-1-16 12.5 INCH THERMAL WATER RECOVERY RUN PD24-31



EA006 024-31-1-136

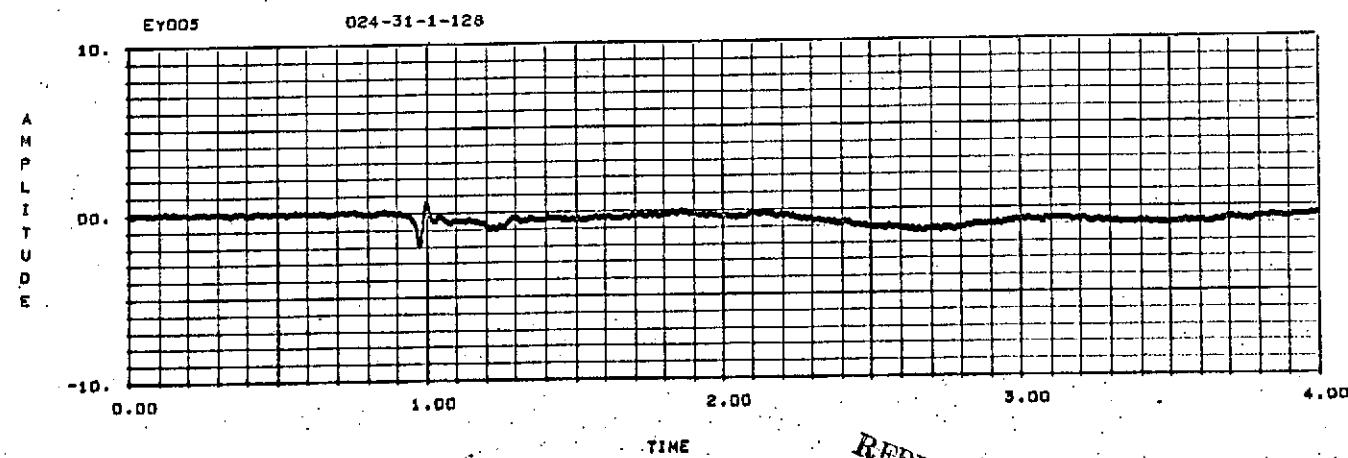
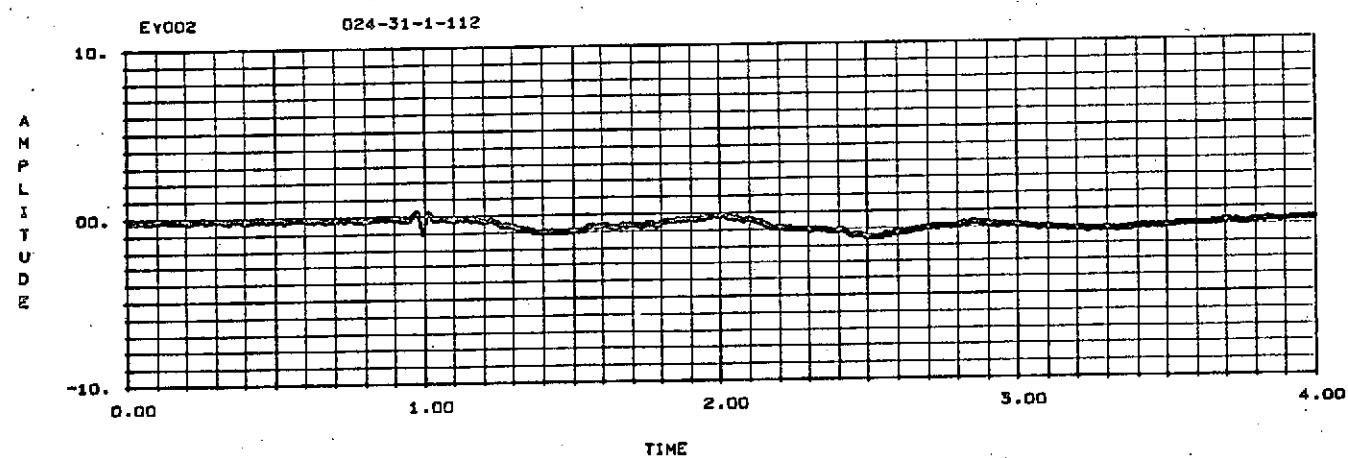
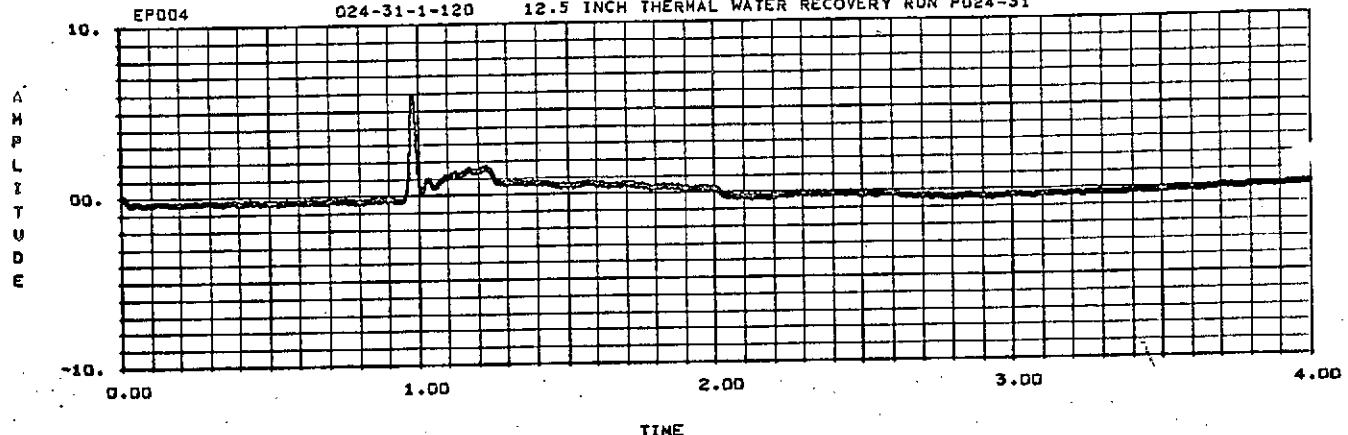


EP001 024-31-1-104



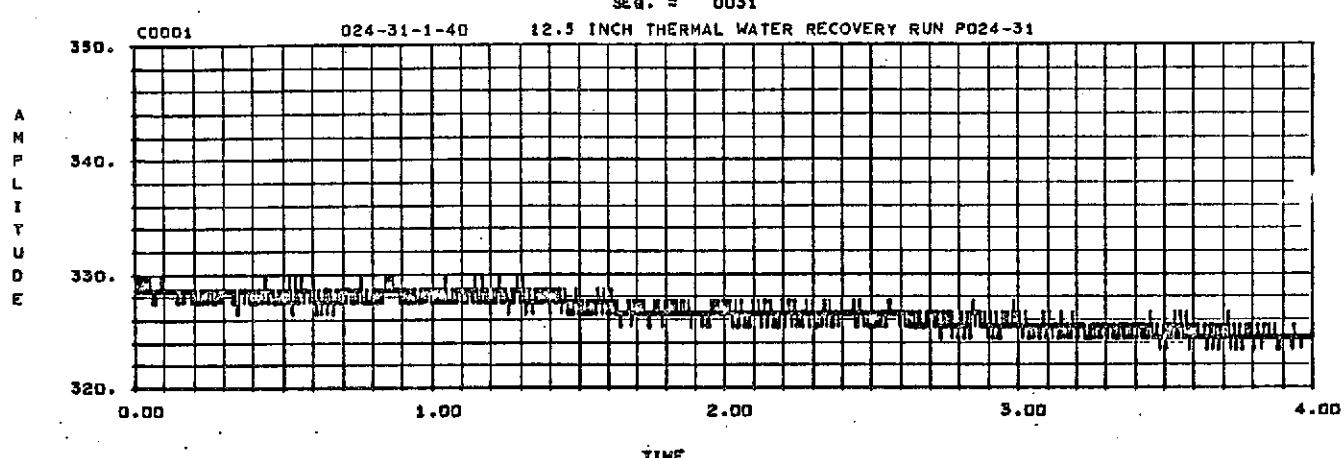
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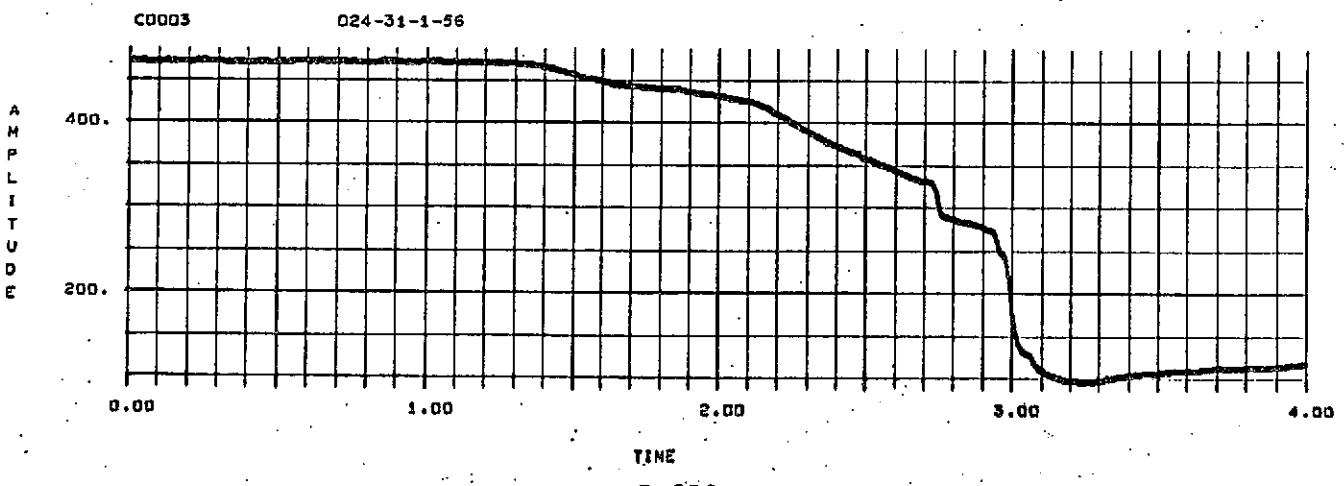
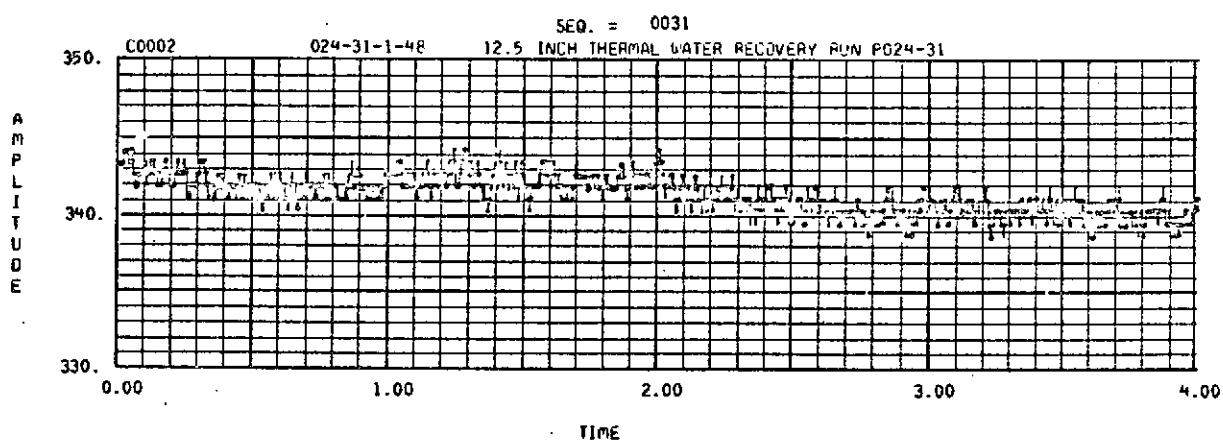


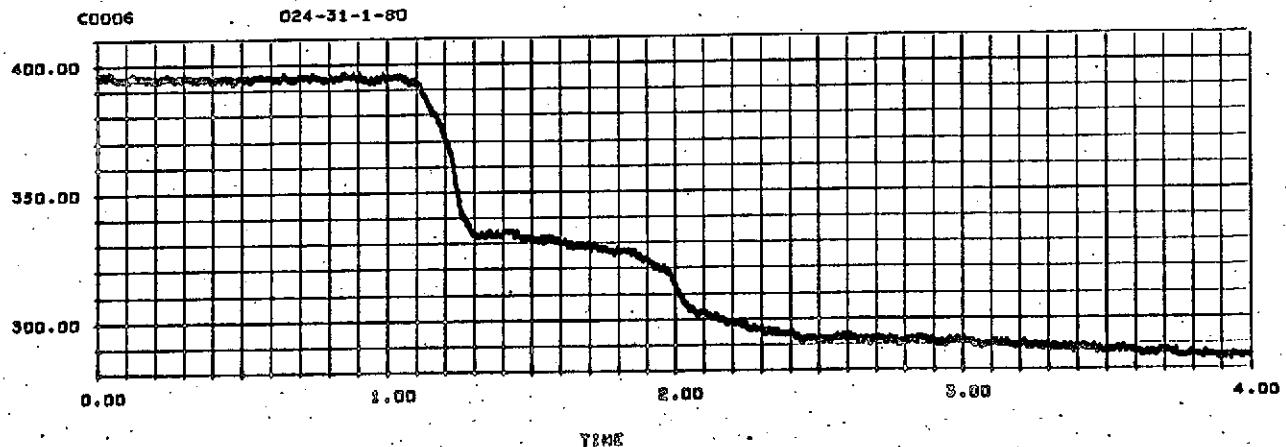
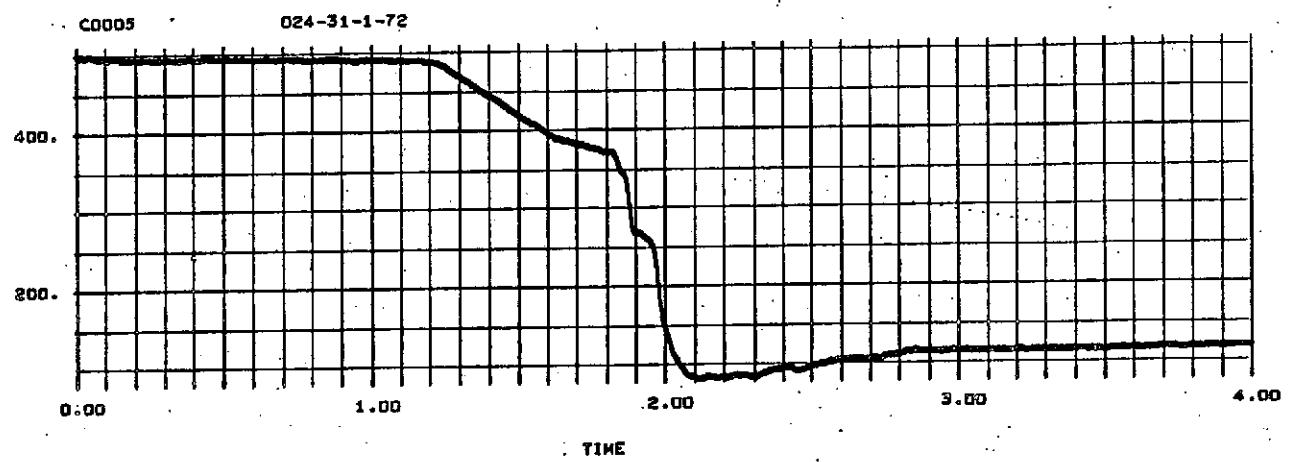
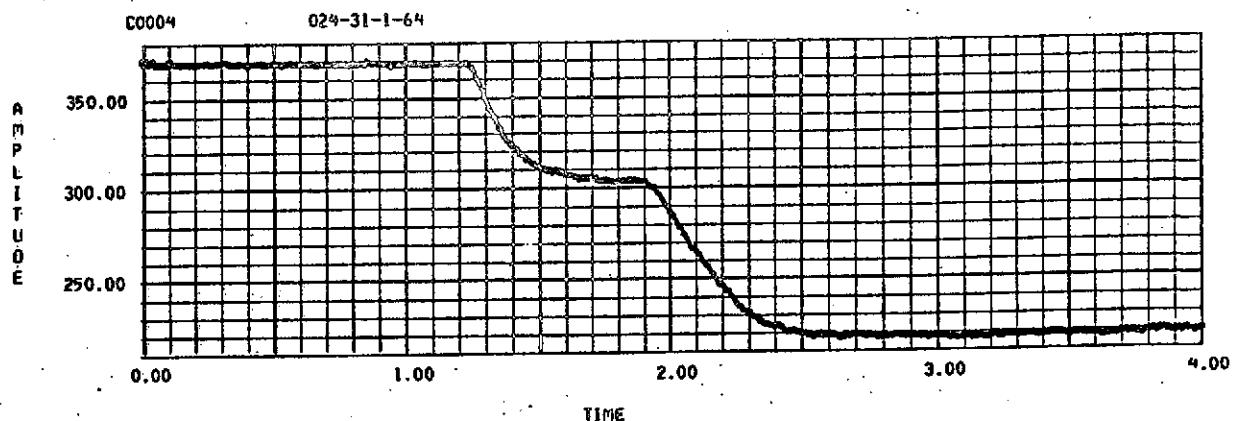
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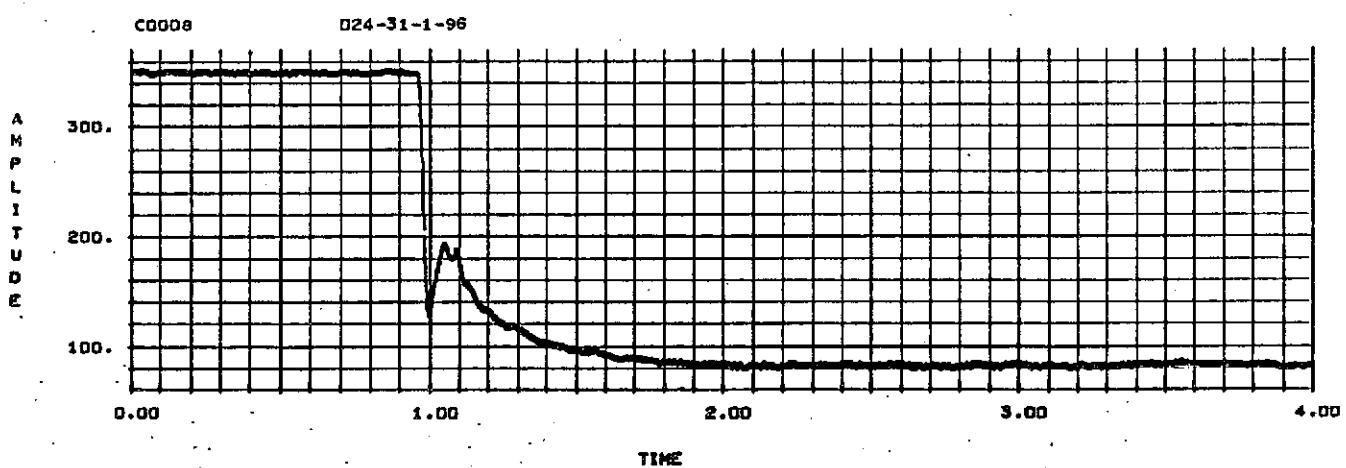
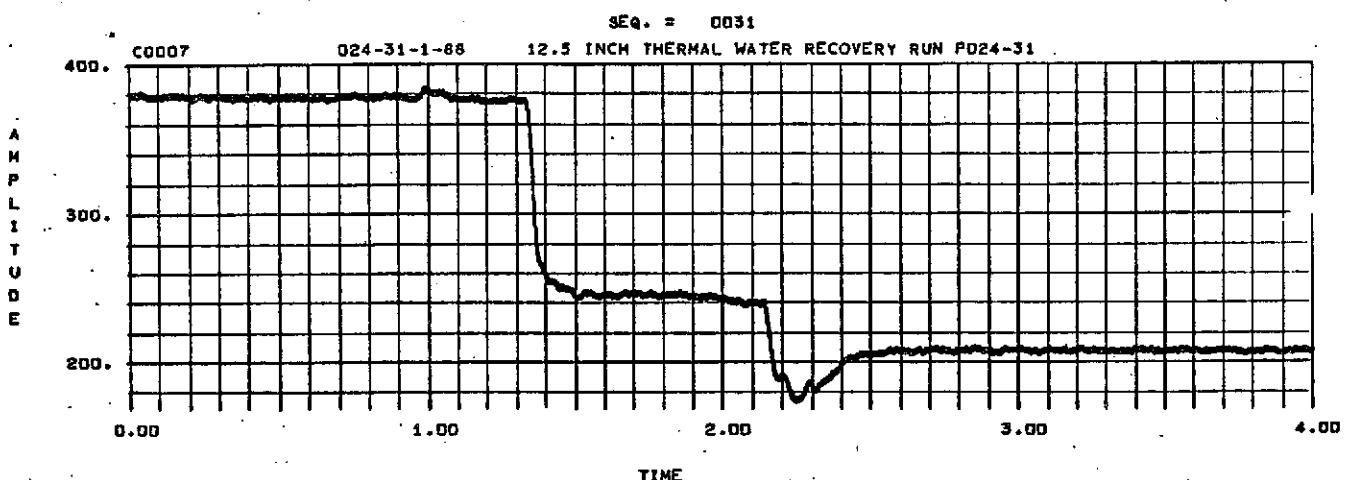
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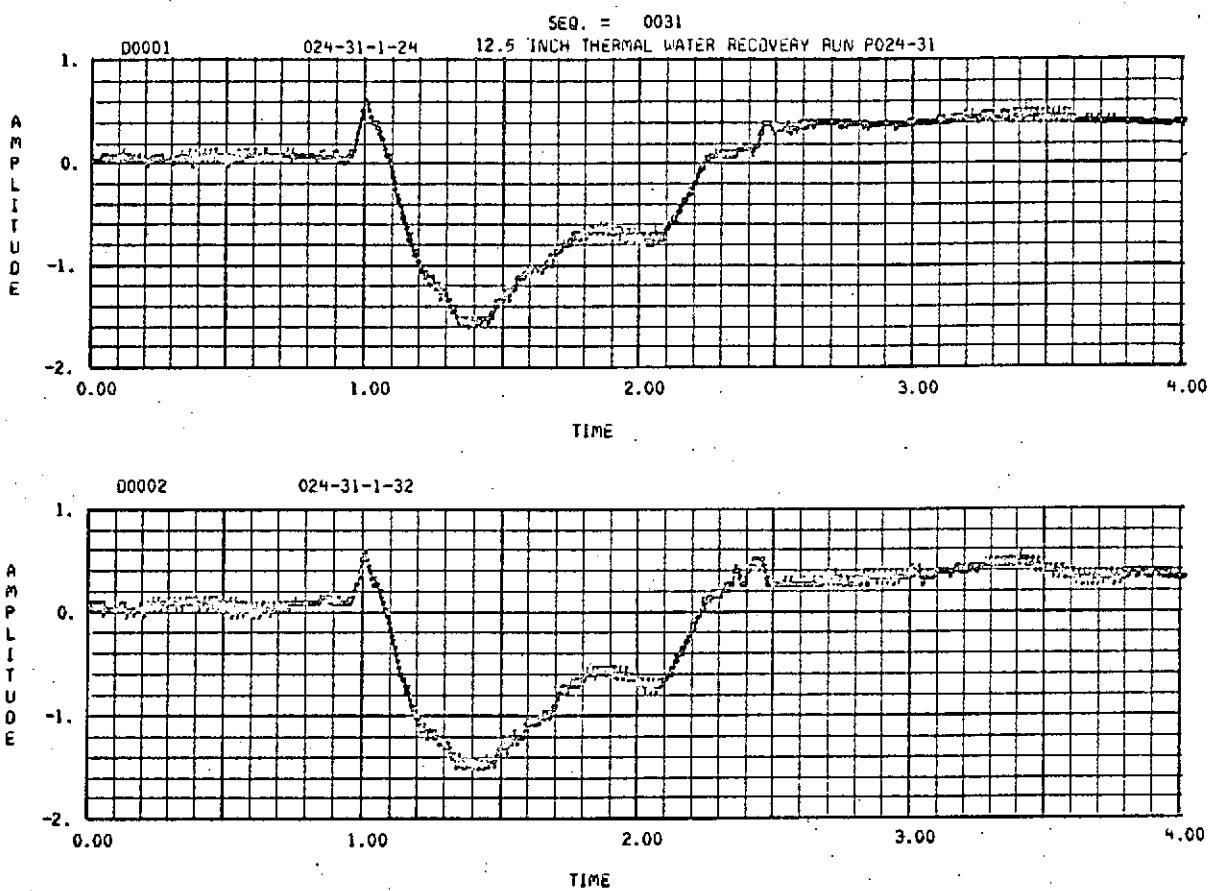




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ORIGINAL PAGE IS POOR





REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

SEQ. = 0031

C0001

024-31-1-40

12.5 INCH THERMAL WATER RECOVERY RUN PD24-31

A
M
P
L
I
T
U
D
E

340.

320.

300.

4.

6.

8.

10.

12.

14.

16.

TIME

C0002

024-31-1-48

A
M
P
L
I
T
U
D
E

360.

340.

320.

4.

6.

8.

10.

12.

14.

16.

TIME

C0003

024-31-1-56

A
M
P
L
I
T
U
D
E

250.00

200.00

150.00

4.

6.

8.

10.

12.

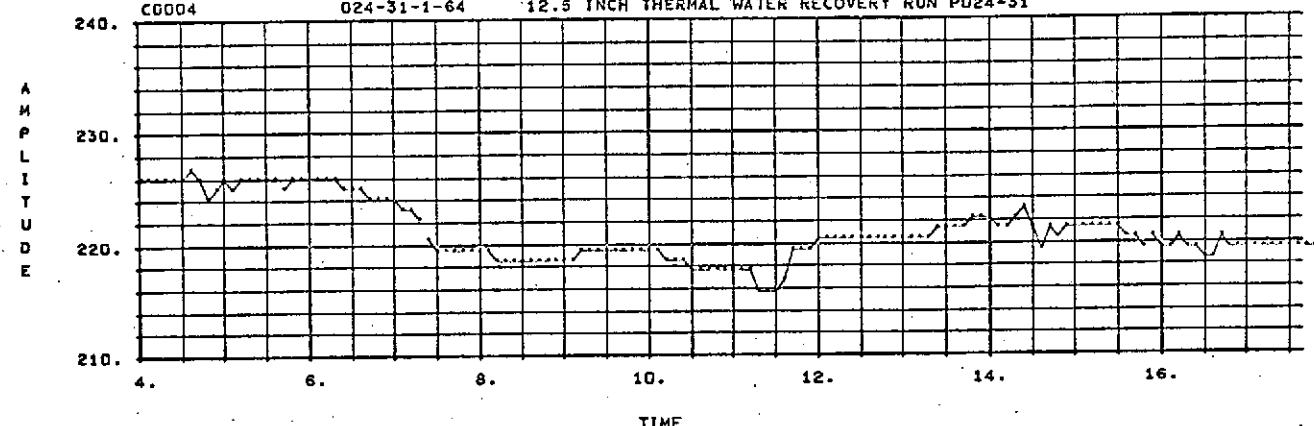
14.

16.

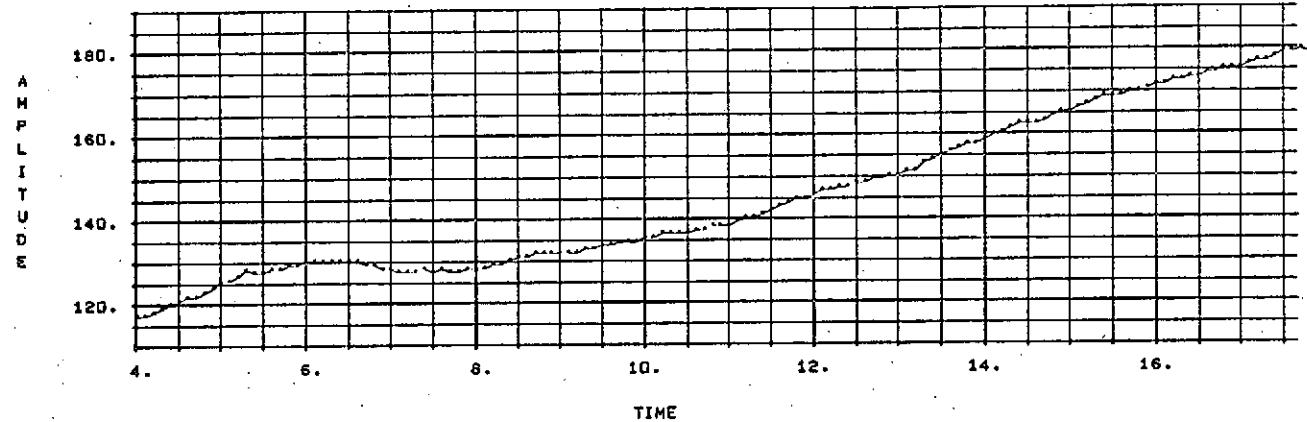
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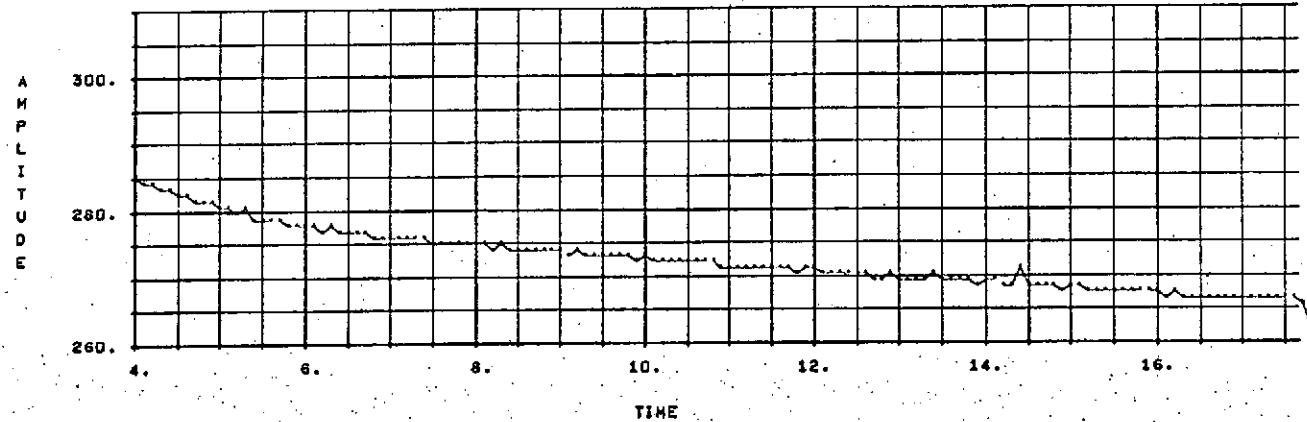
C0004 024-31-1-64 12.5 INCH THERMAL WATER RECOVERY RUN P024-31



C0005 024-31-1-72

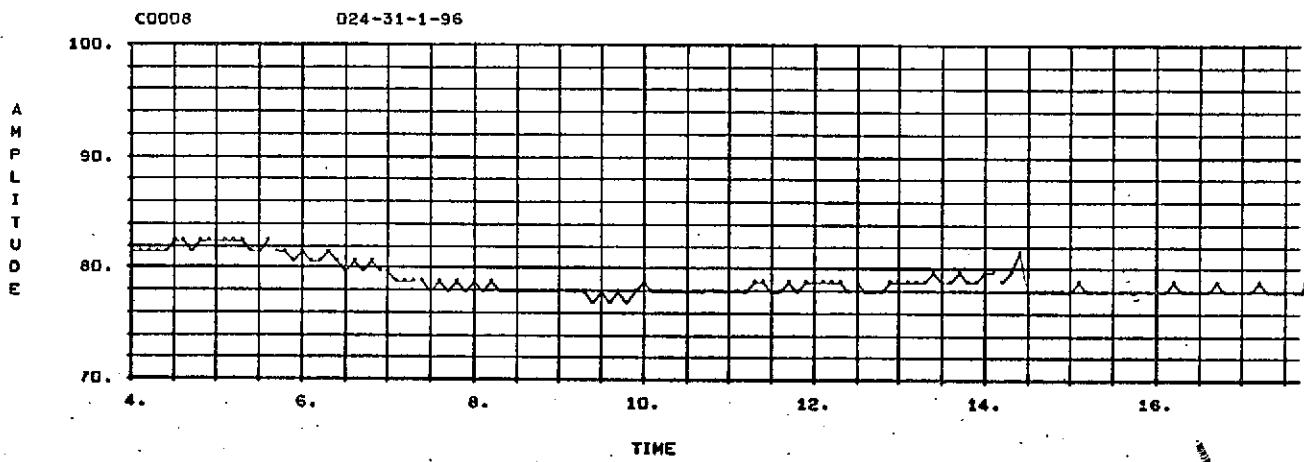
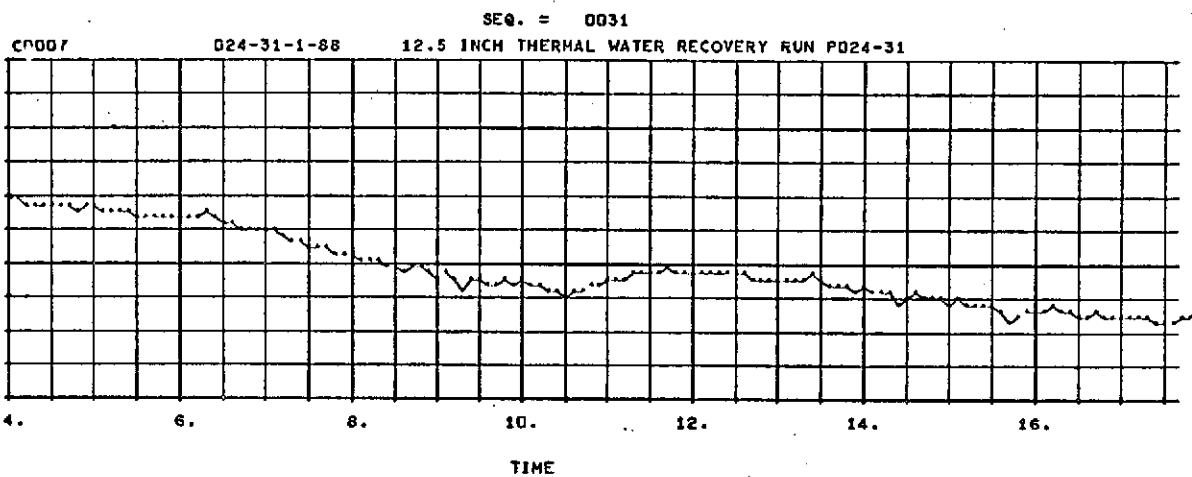


C0006 024-31-1-80



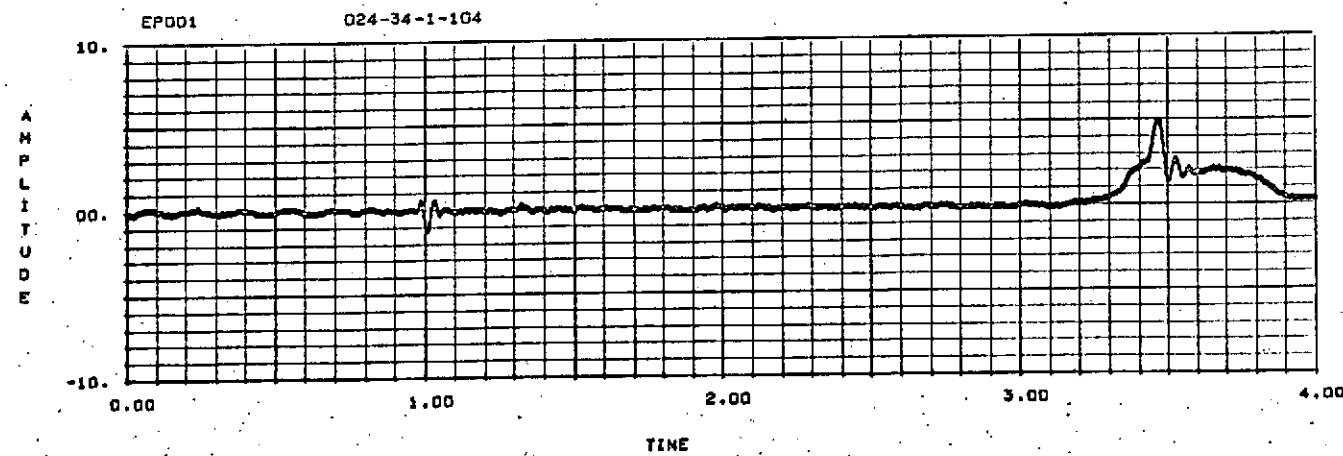
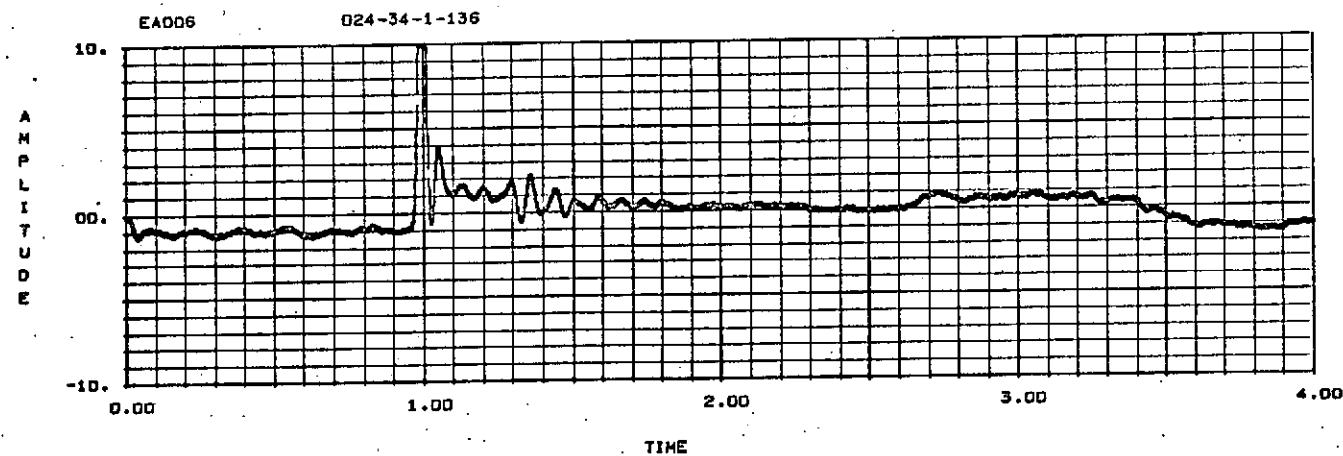
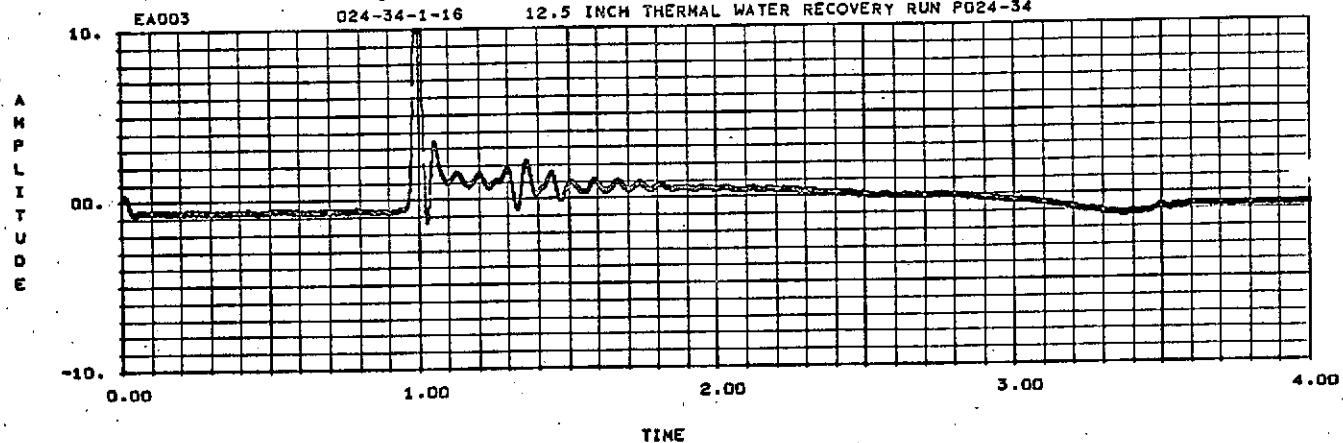
B-257

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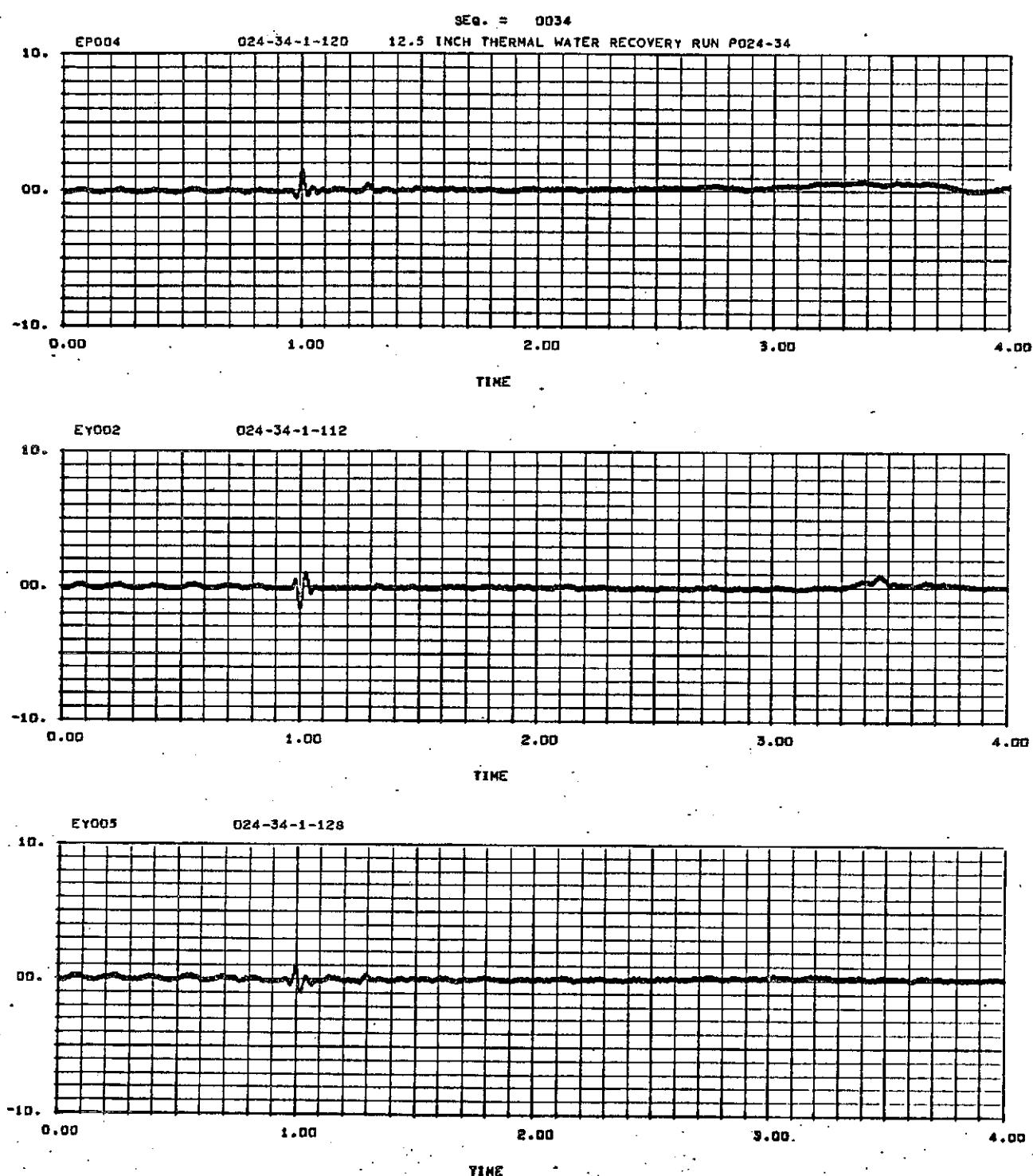
SEQ. = 0034

024-34-1-16 12.5 INCH THERMAL WATER RECOVERY RUN P024-34



B-259

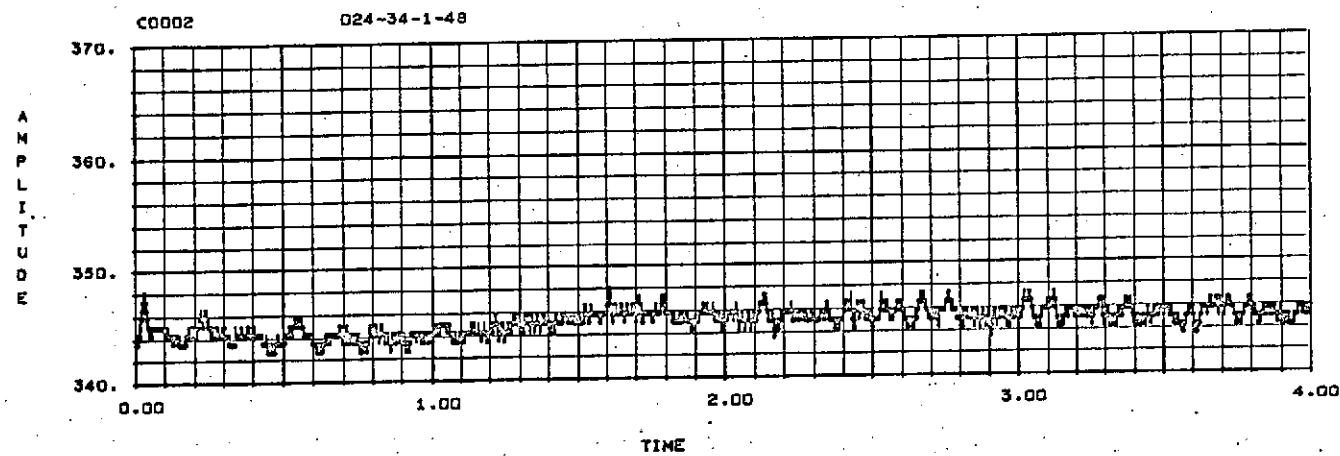
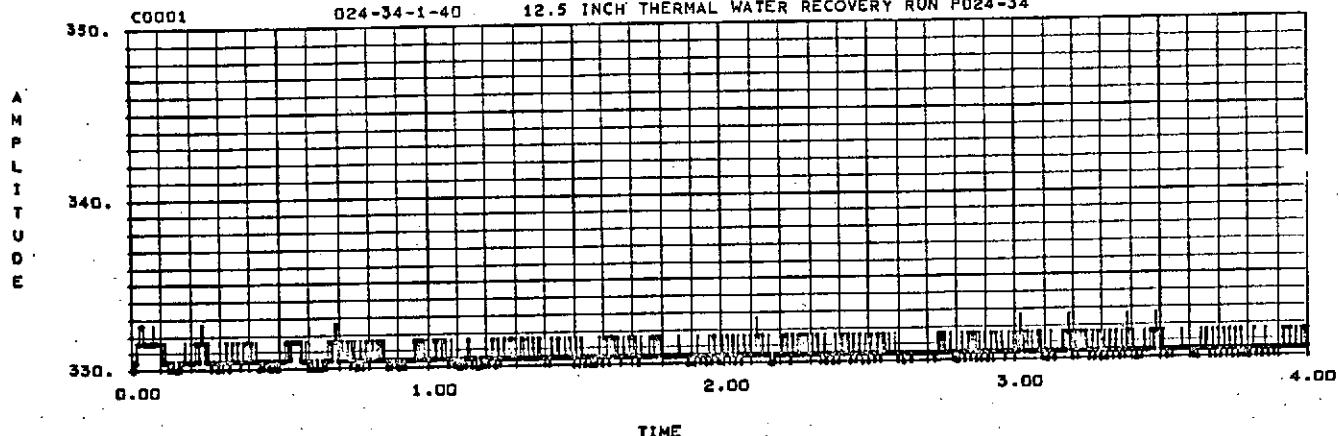
REPRODUCIBILITY OF THE
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B-260

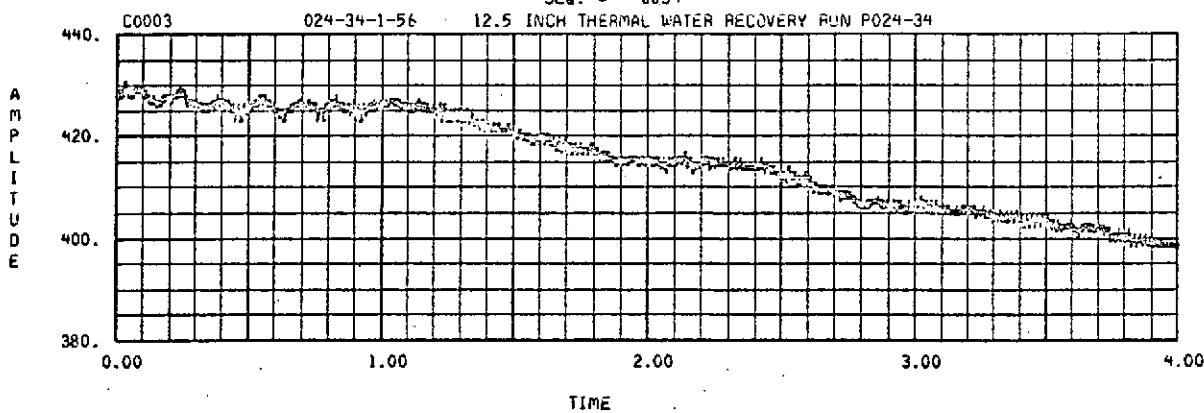
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024-34-1-40 12.5 INCH THERMAL WATER RECOVERY RUN P024-34



SEQ. = 0034

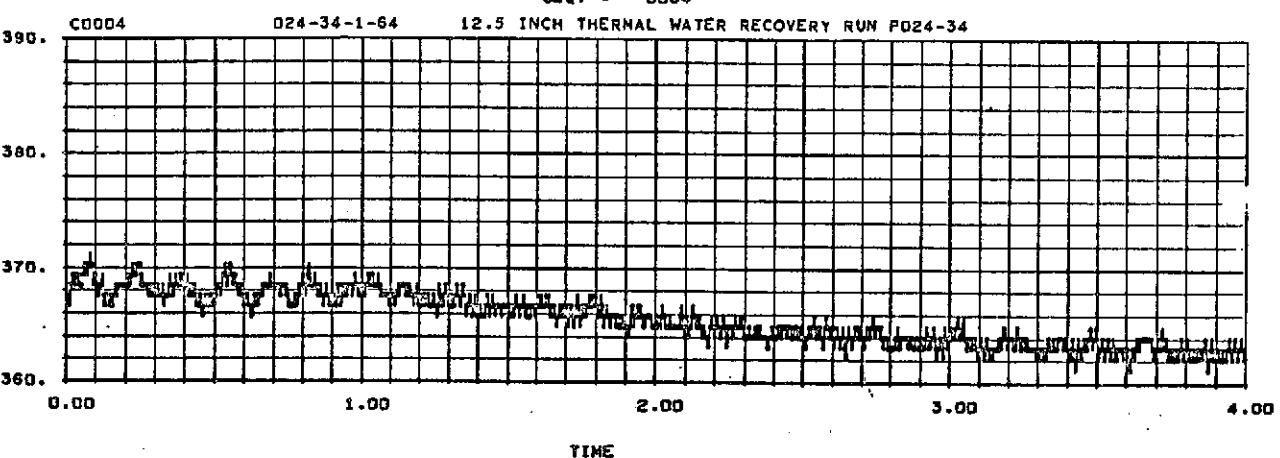
024-34-1-56 12.5 INCH THERMAL WATER RECOVERY RUN P024-34



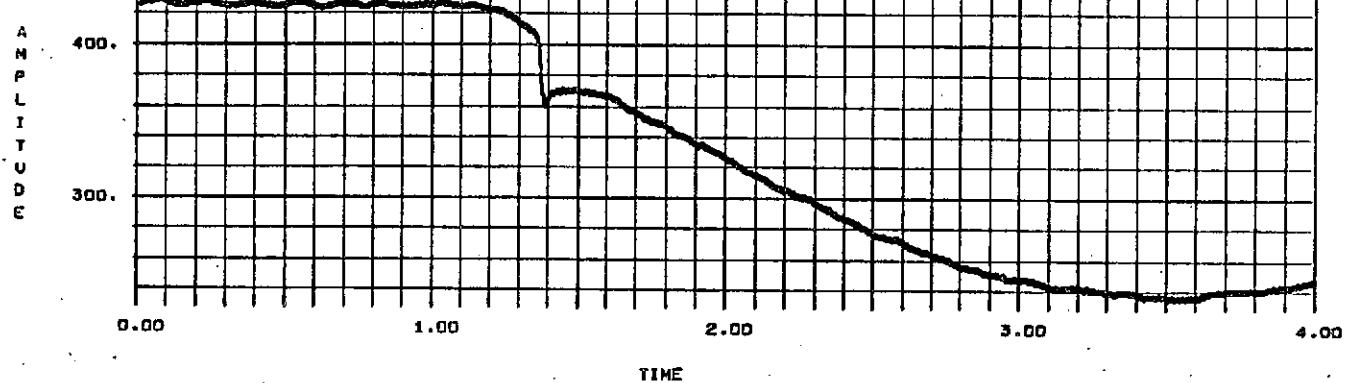
B-261

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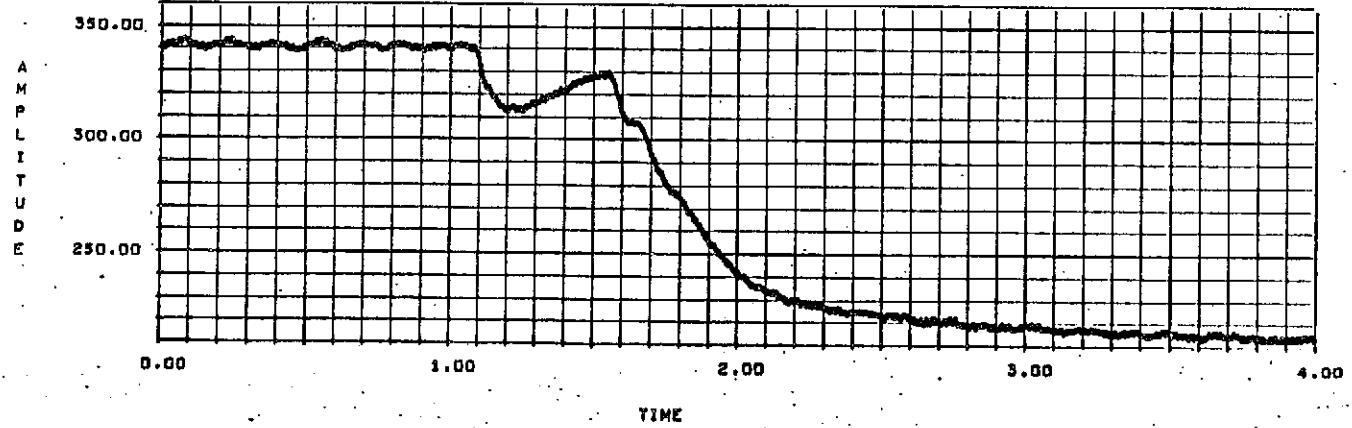
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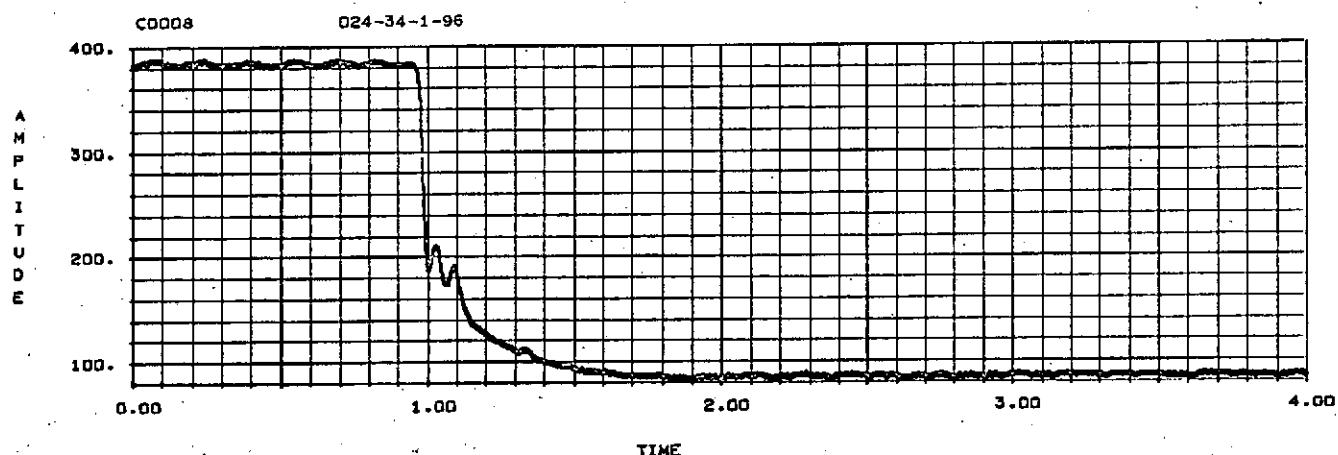
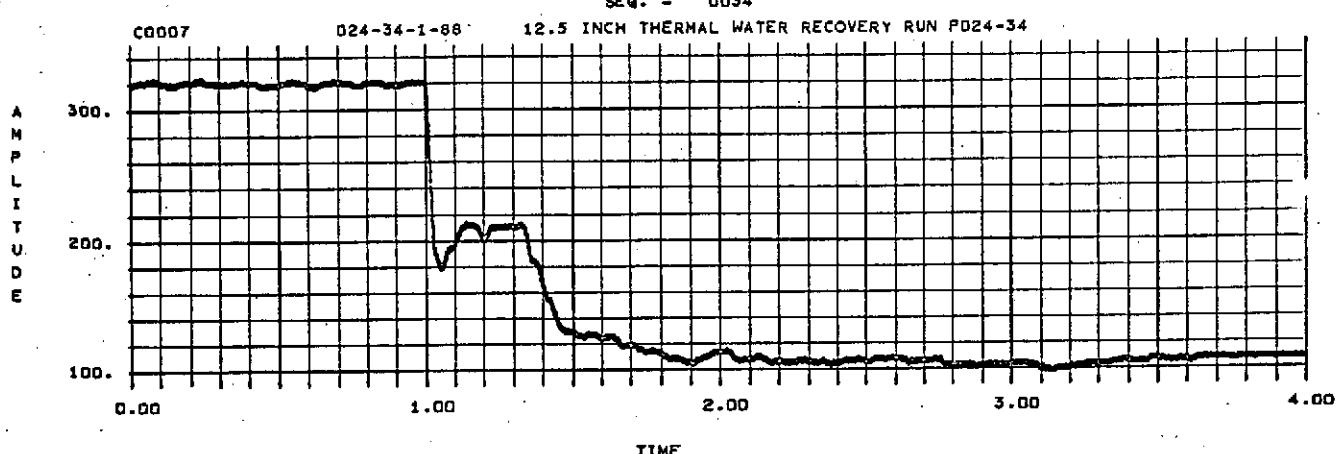
C0005 024-34-1-72



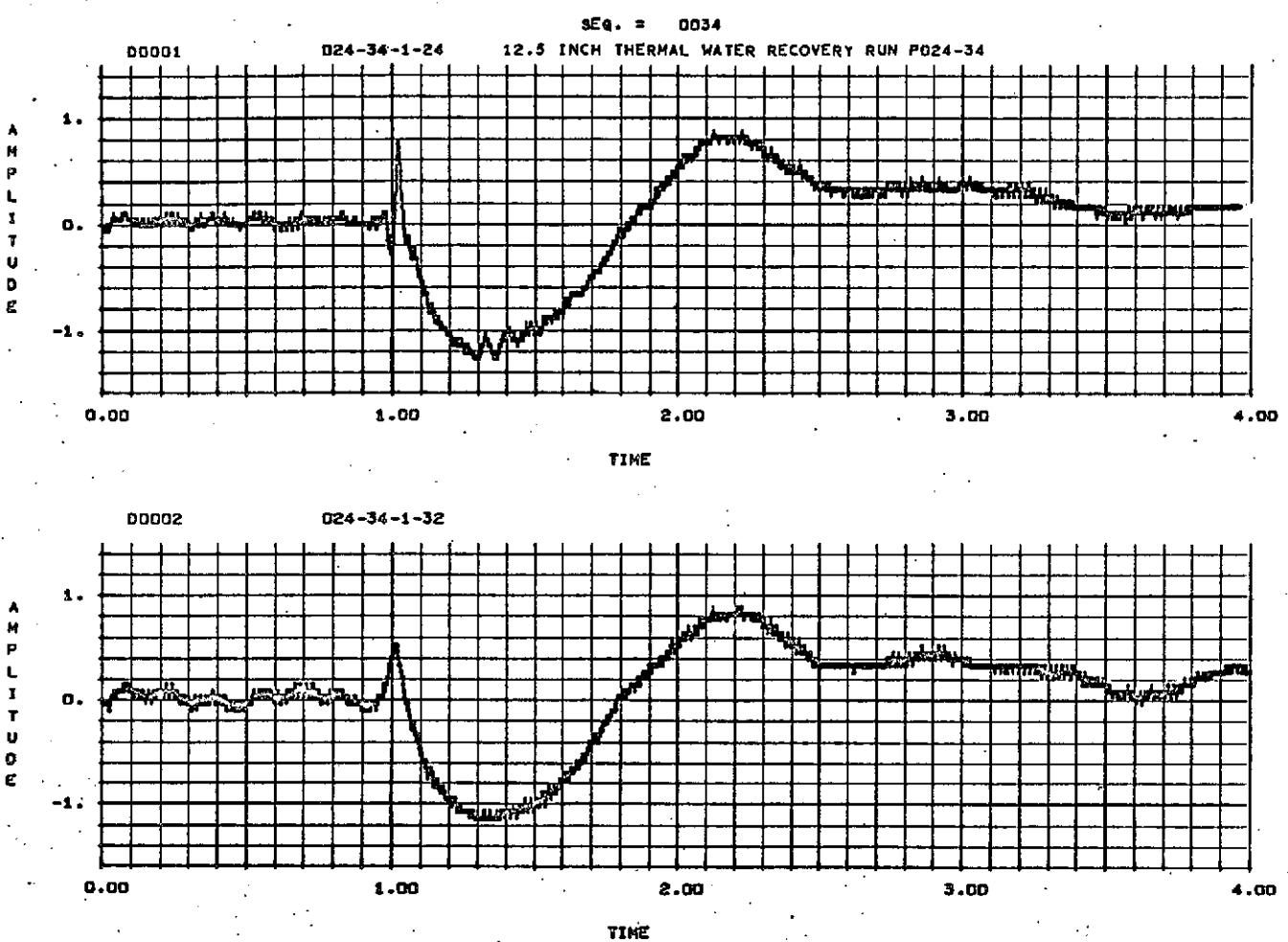
C0006 024-34-1-80

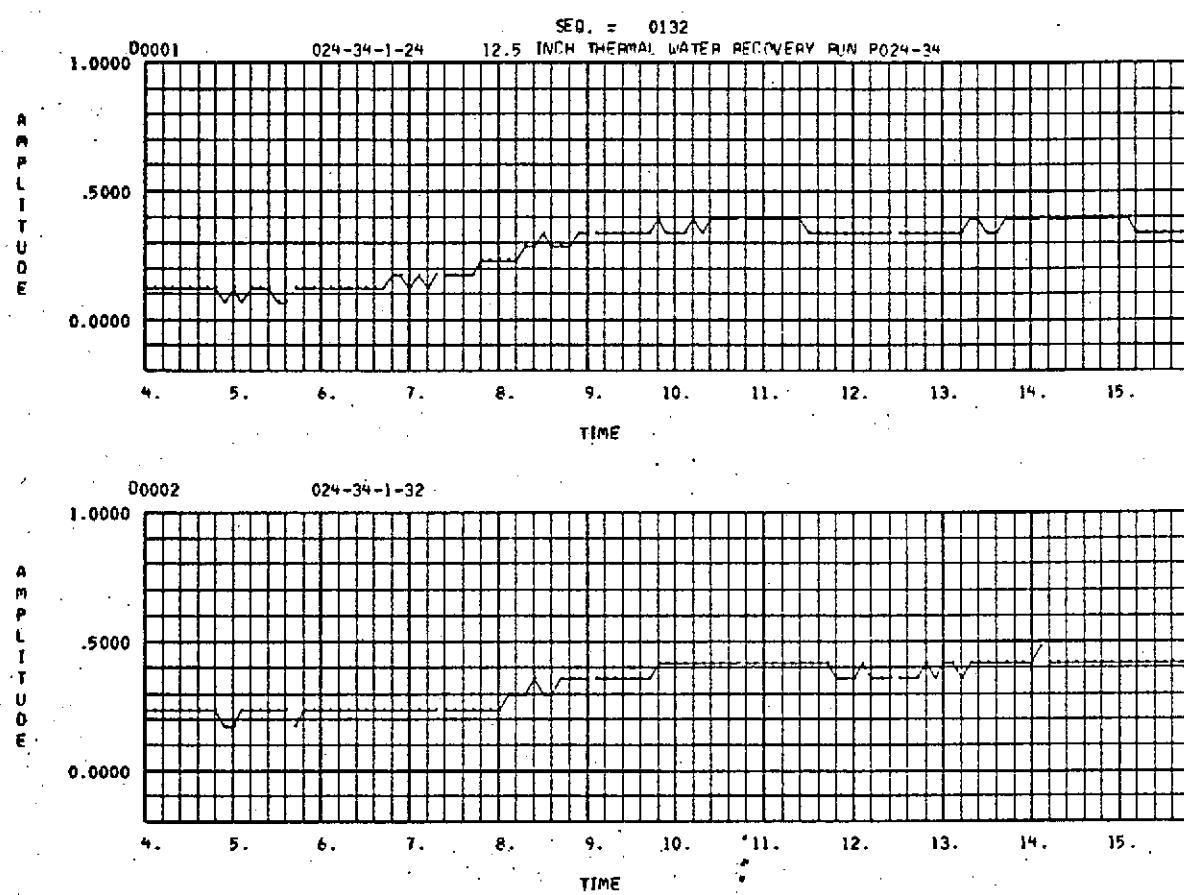


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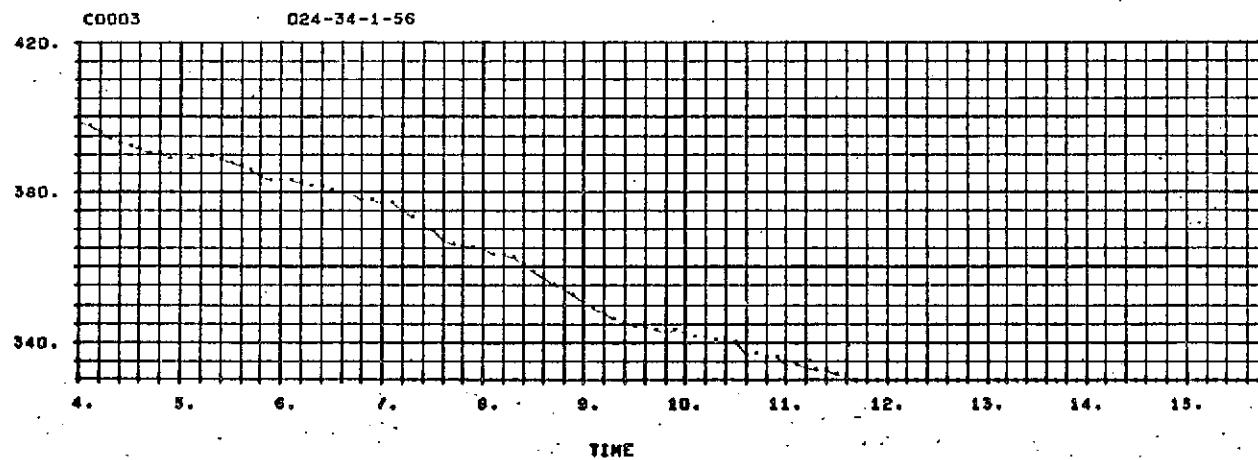
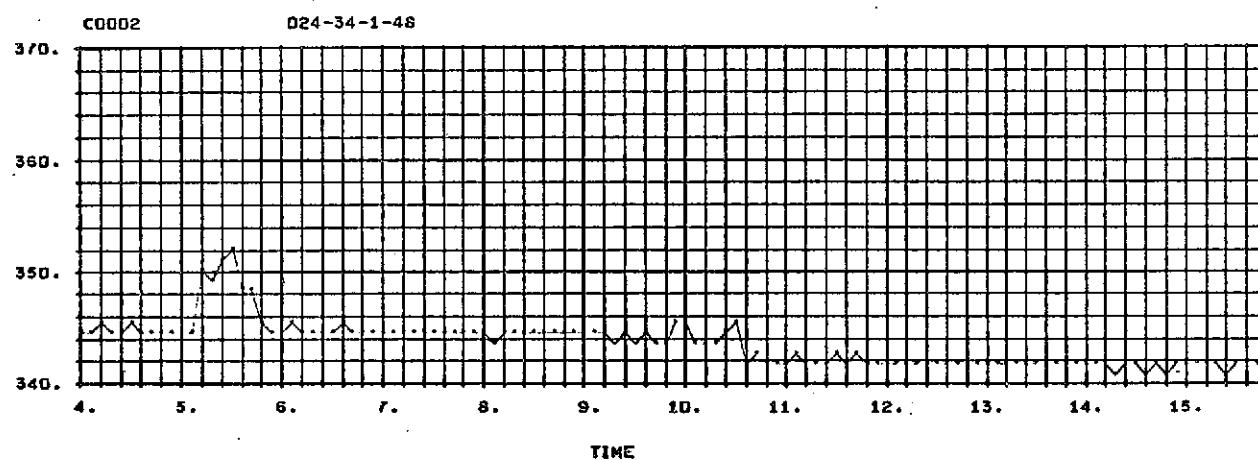
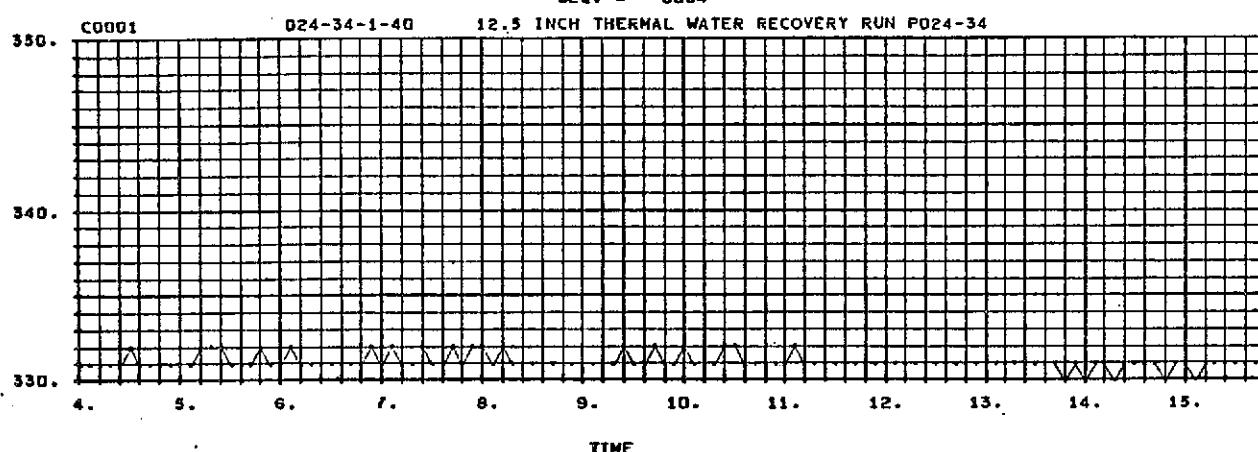


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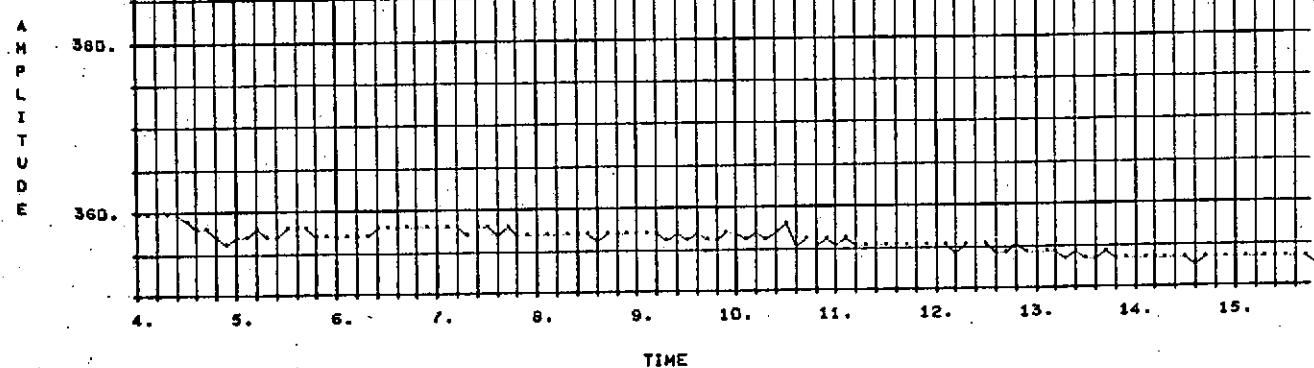




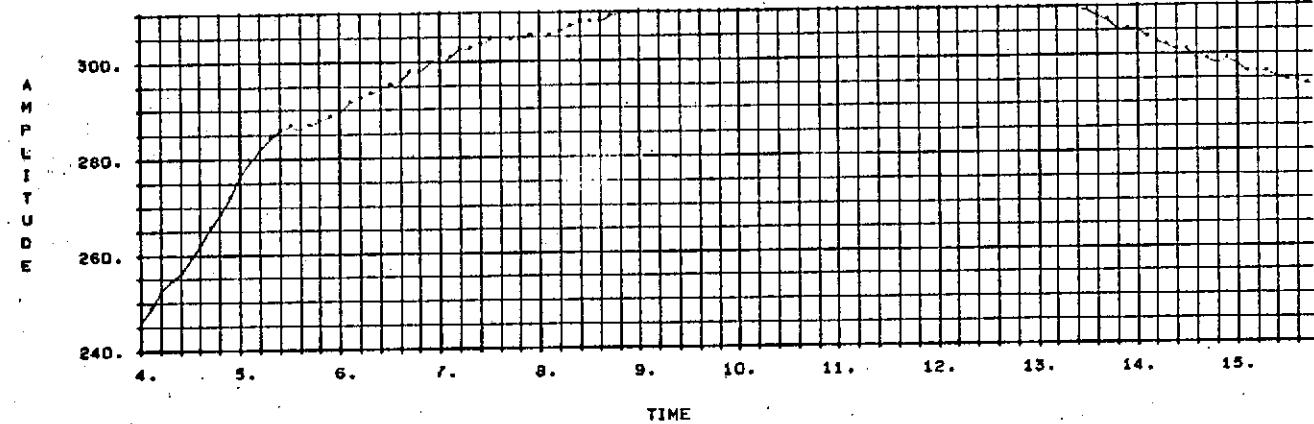
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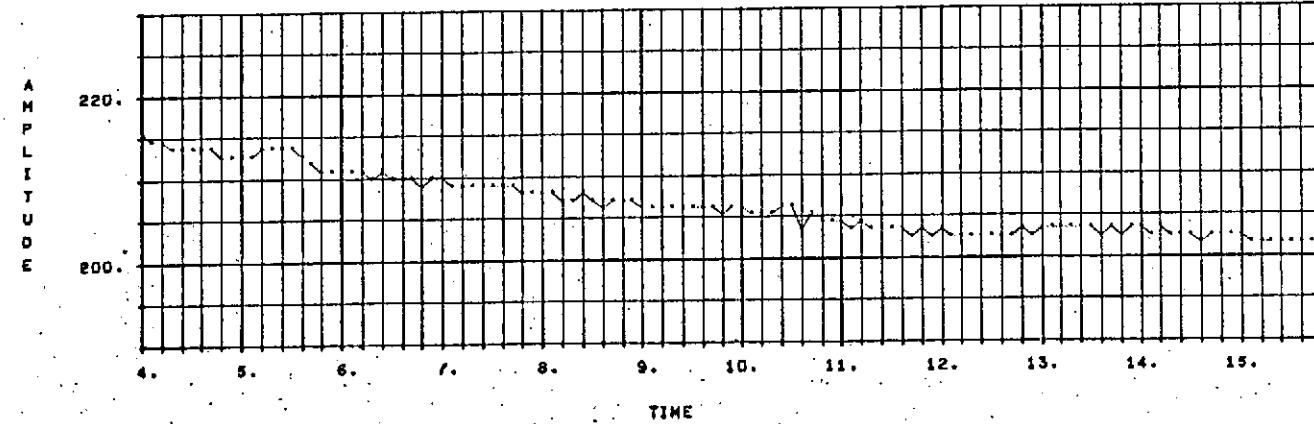
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C0004 024-34-1-64 12.5 INCH THERMAL WATER RECOVERY RUN P024-34



C0005 024-34-1-72

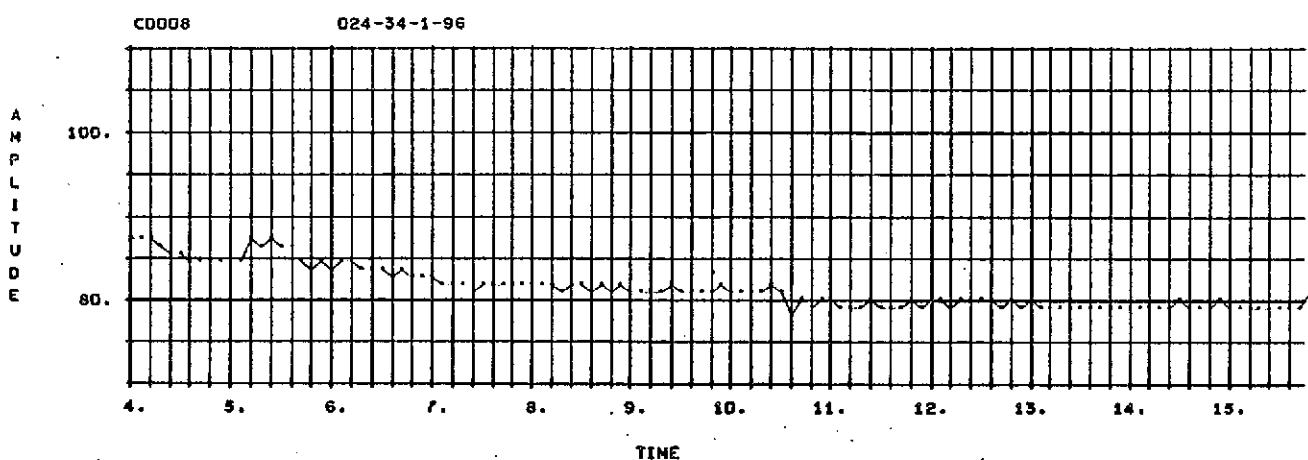
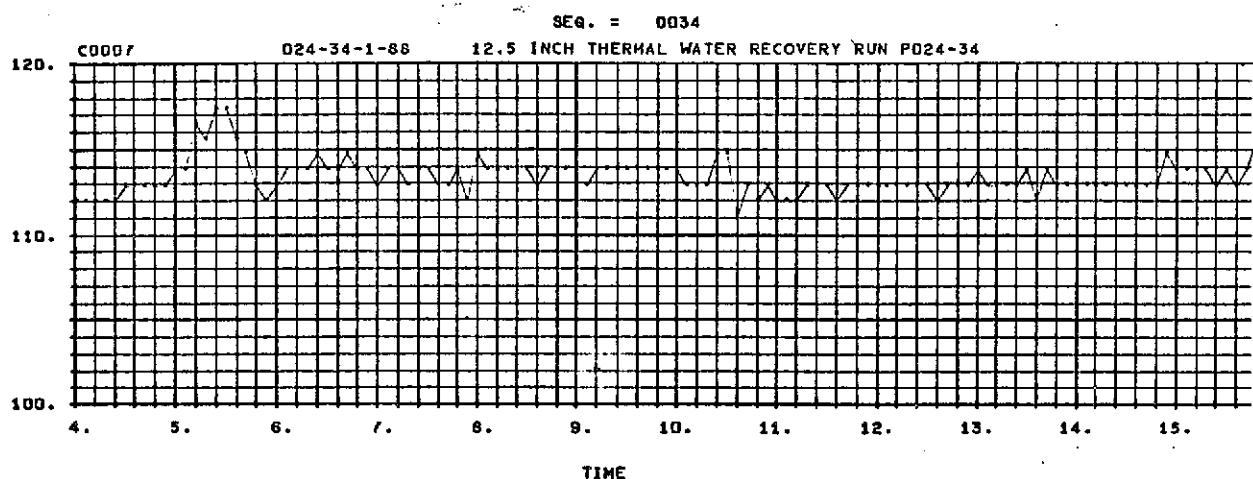


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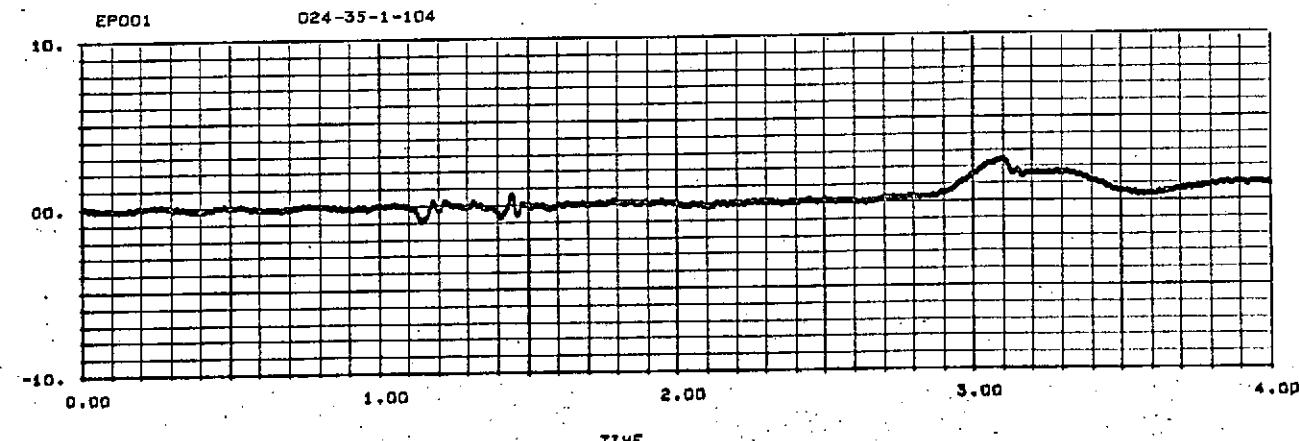
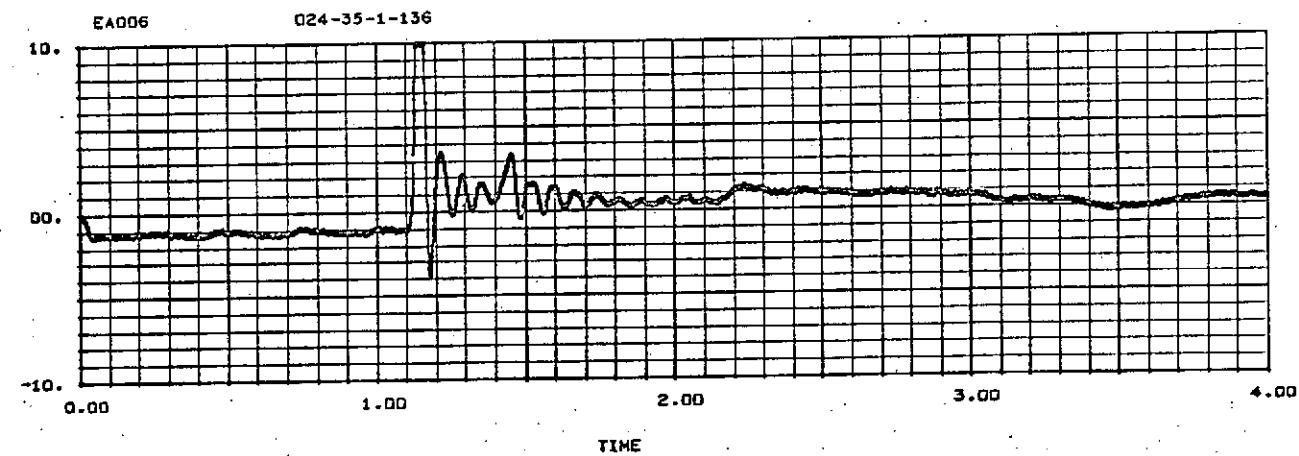
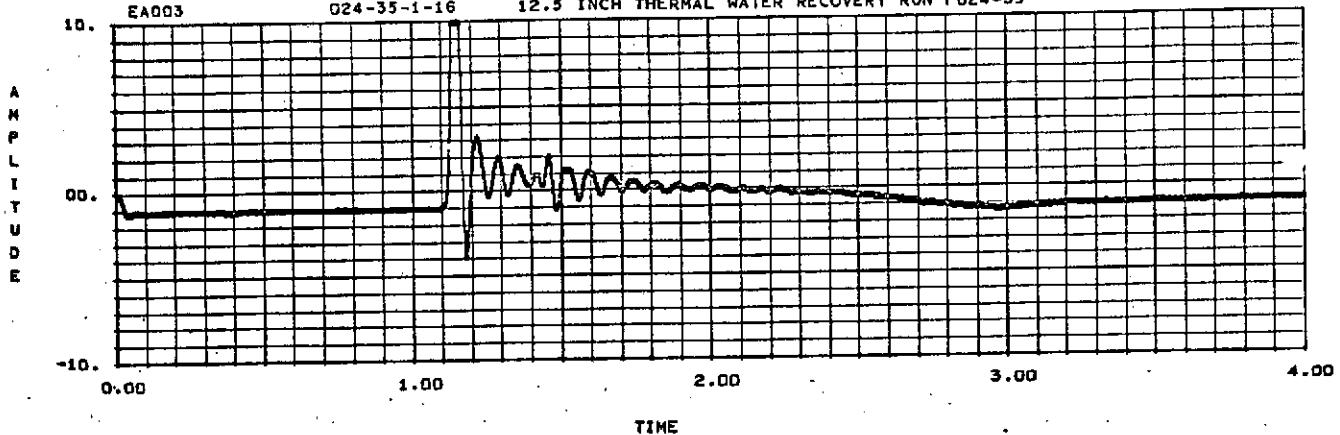
E-267

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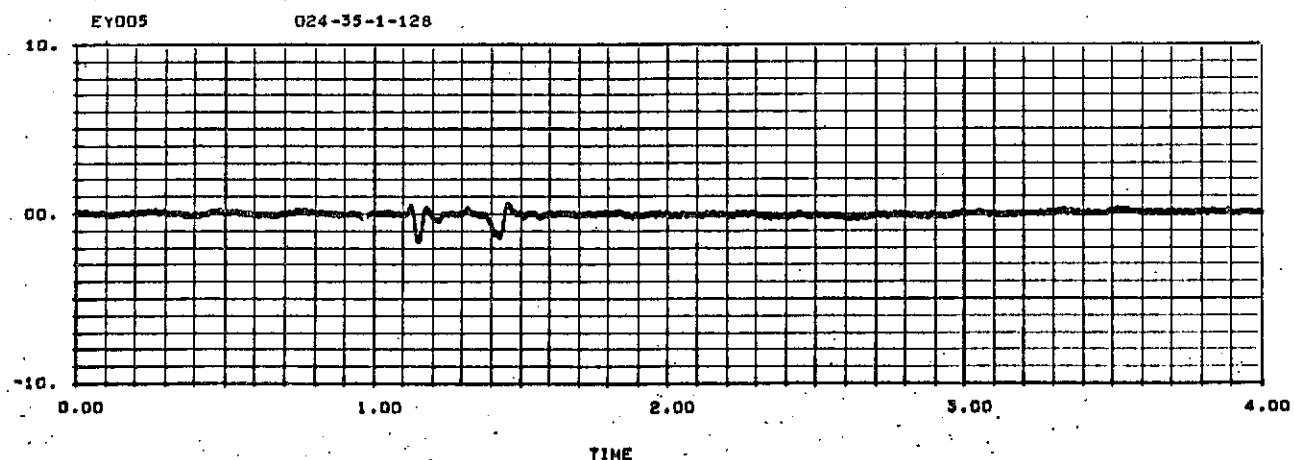
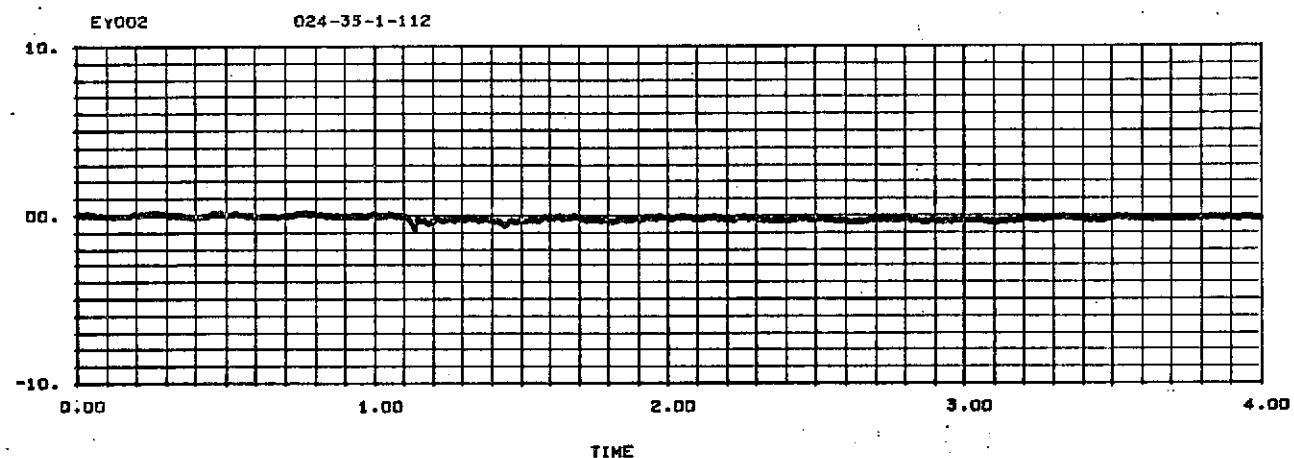
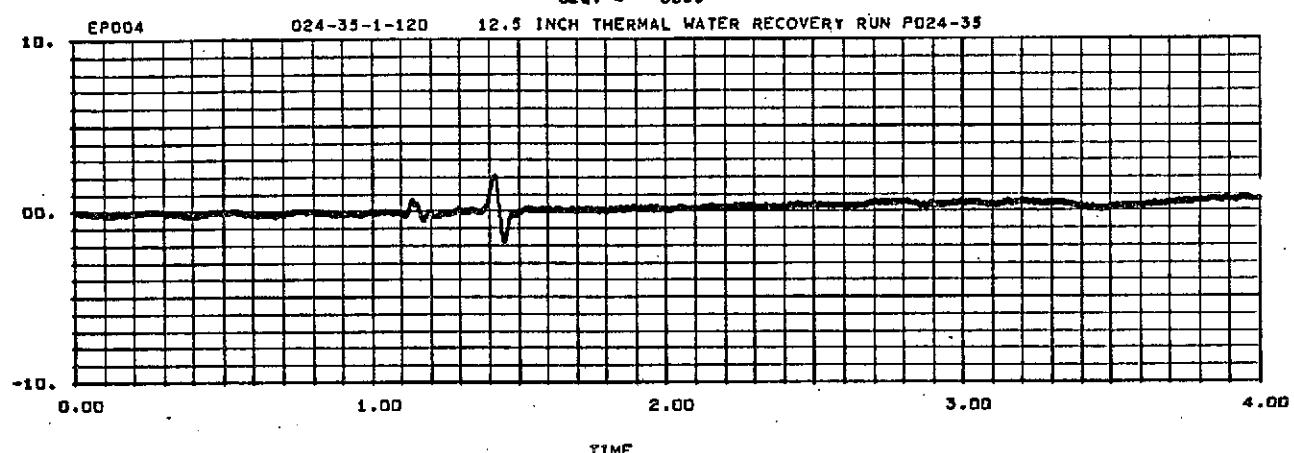
024-35-1-16 12.5 INCH THERMAL WATER RECOVERY RUN P024-35

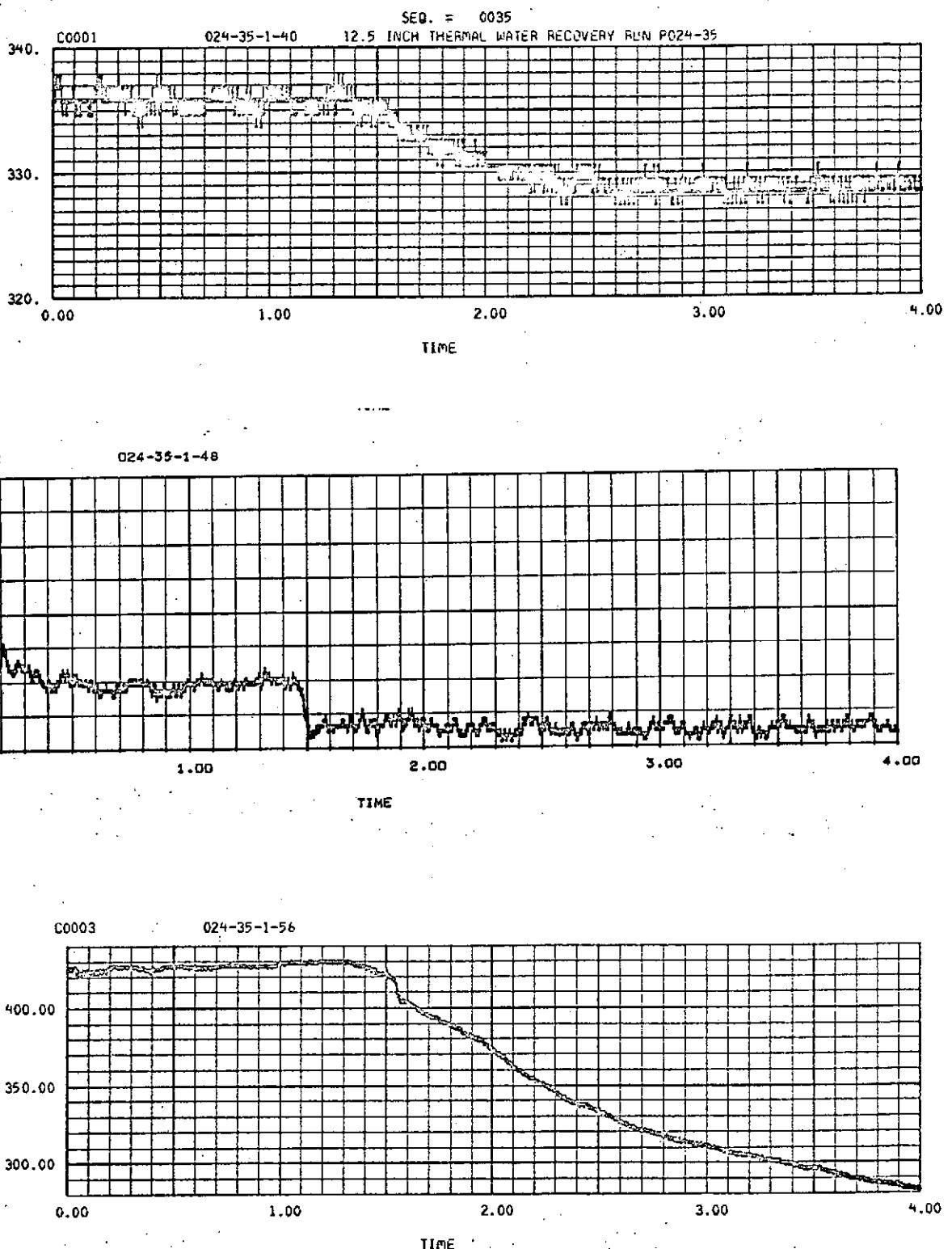


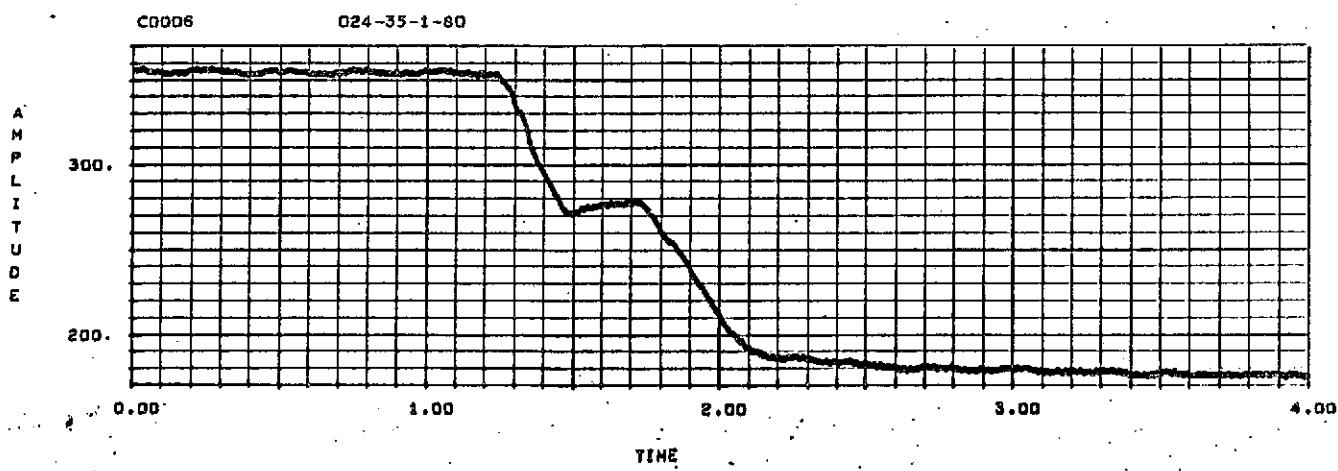
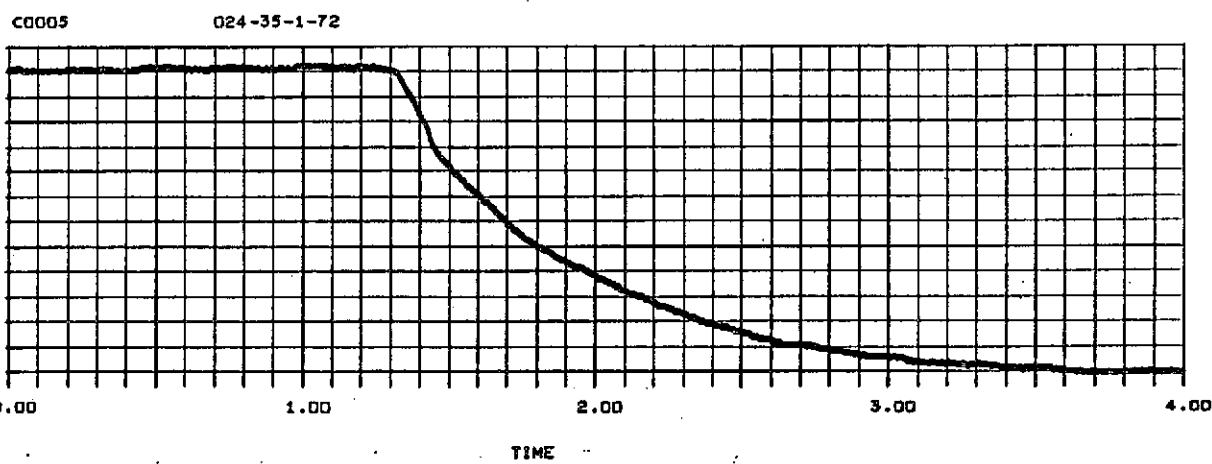
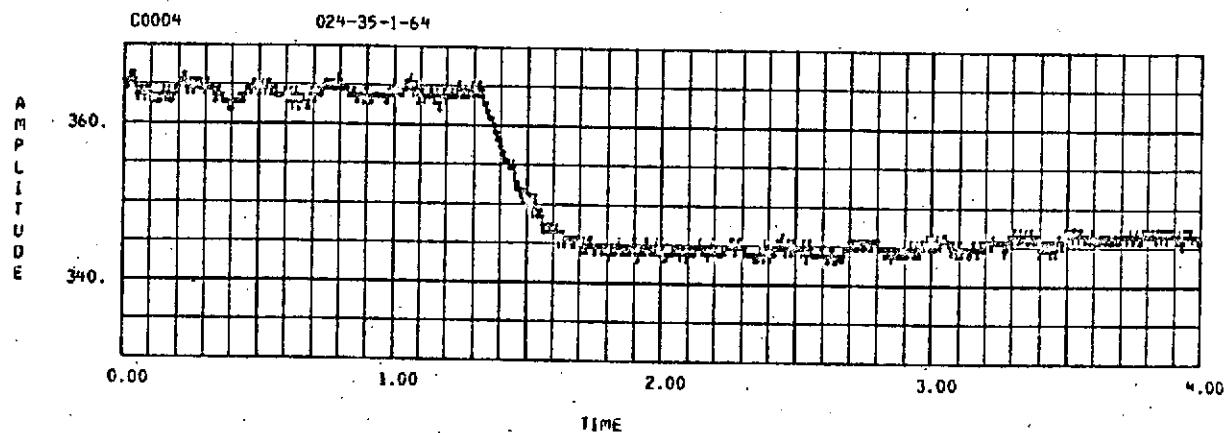
B-269

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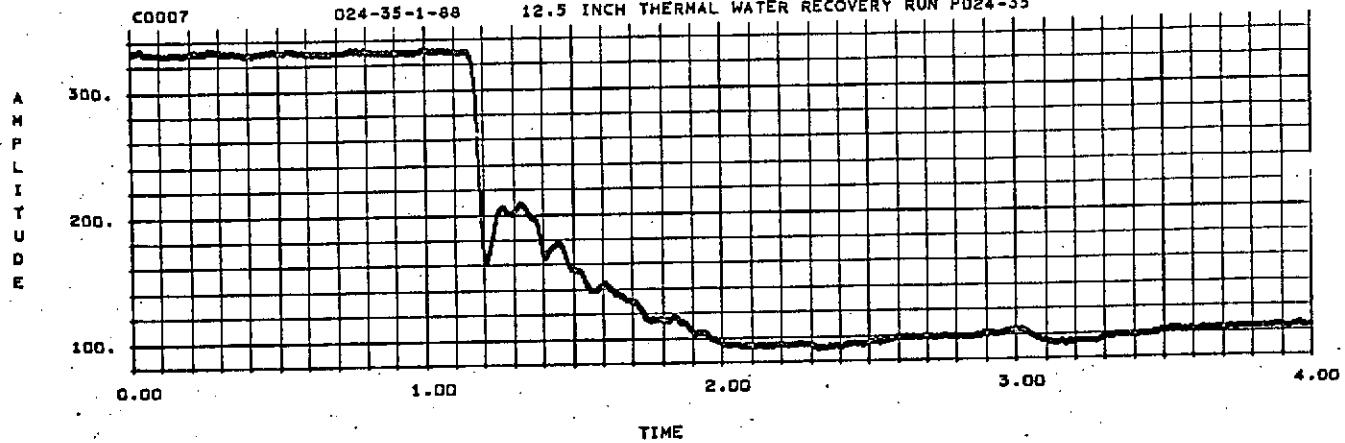




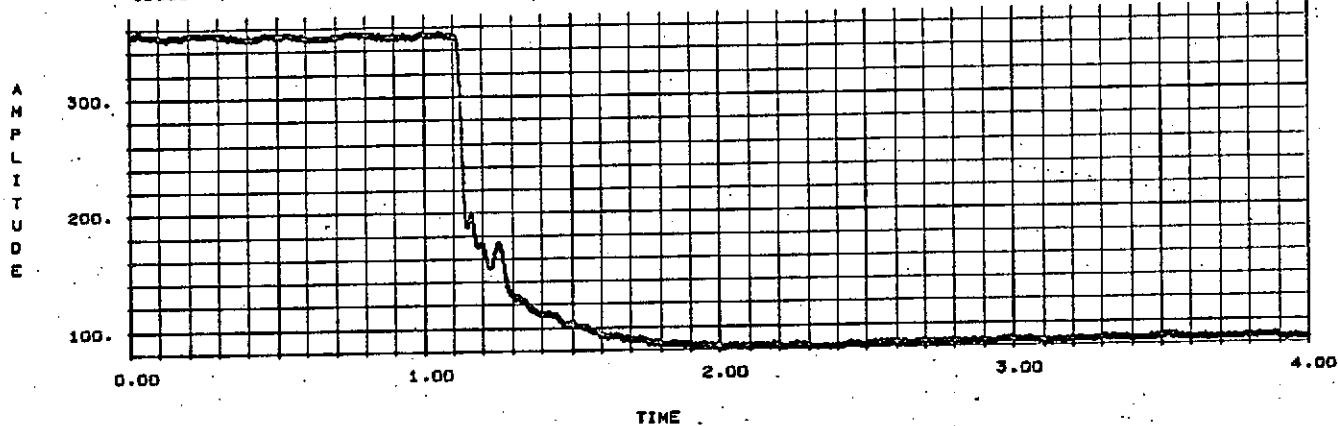


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024-35-1-88 12.5 INCH THERMAL WATER RECOVERY RUN P024-35

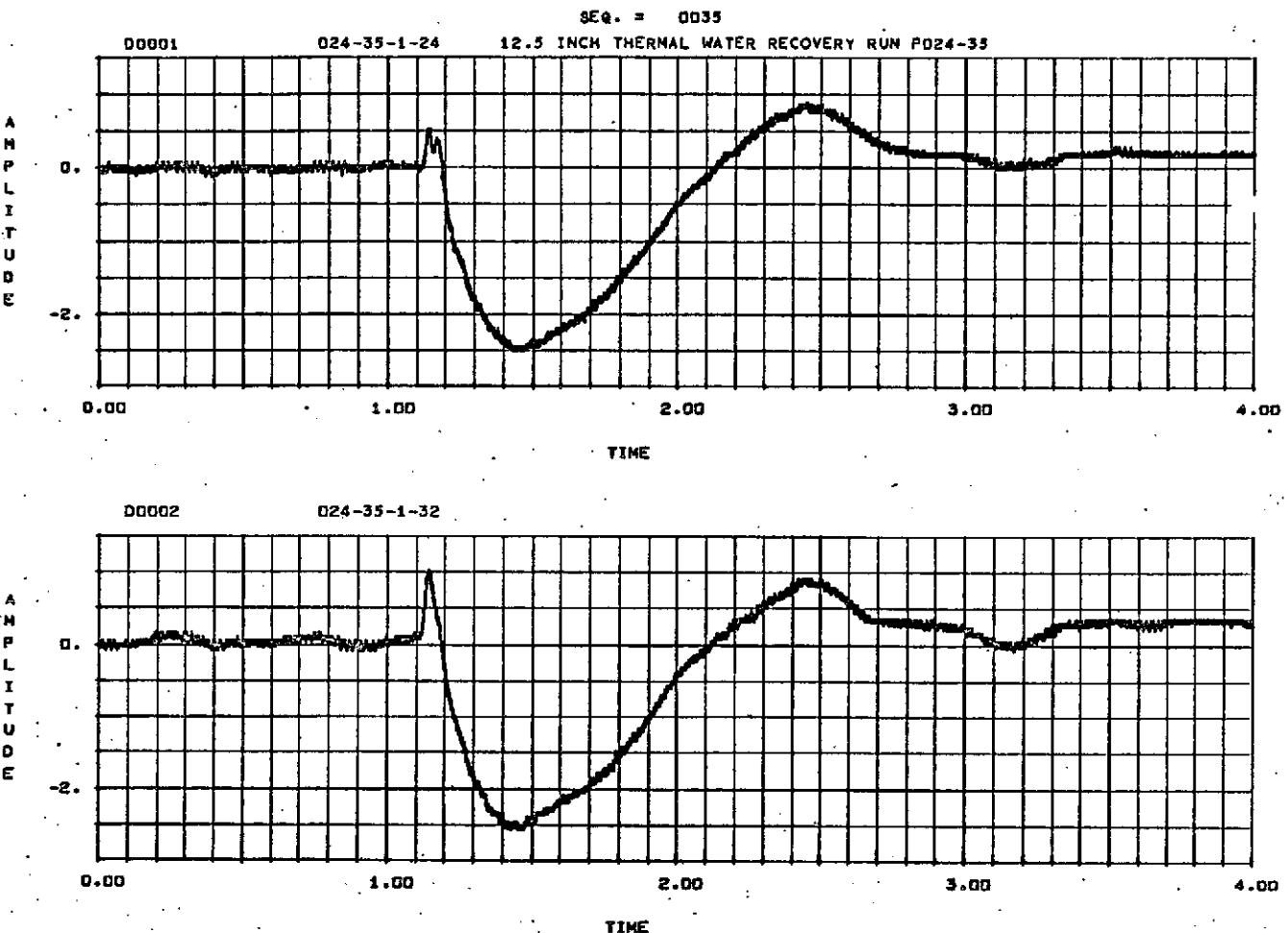


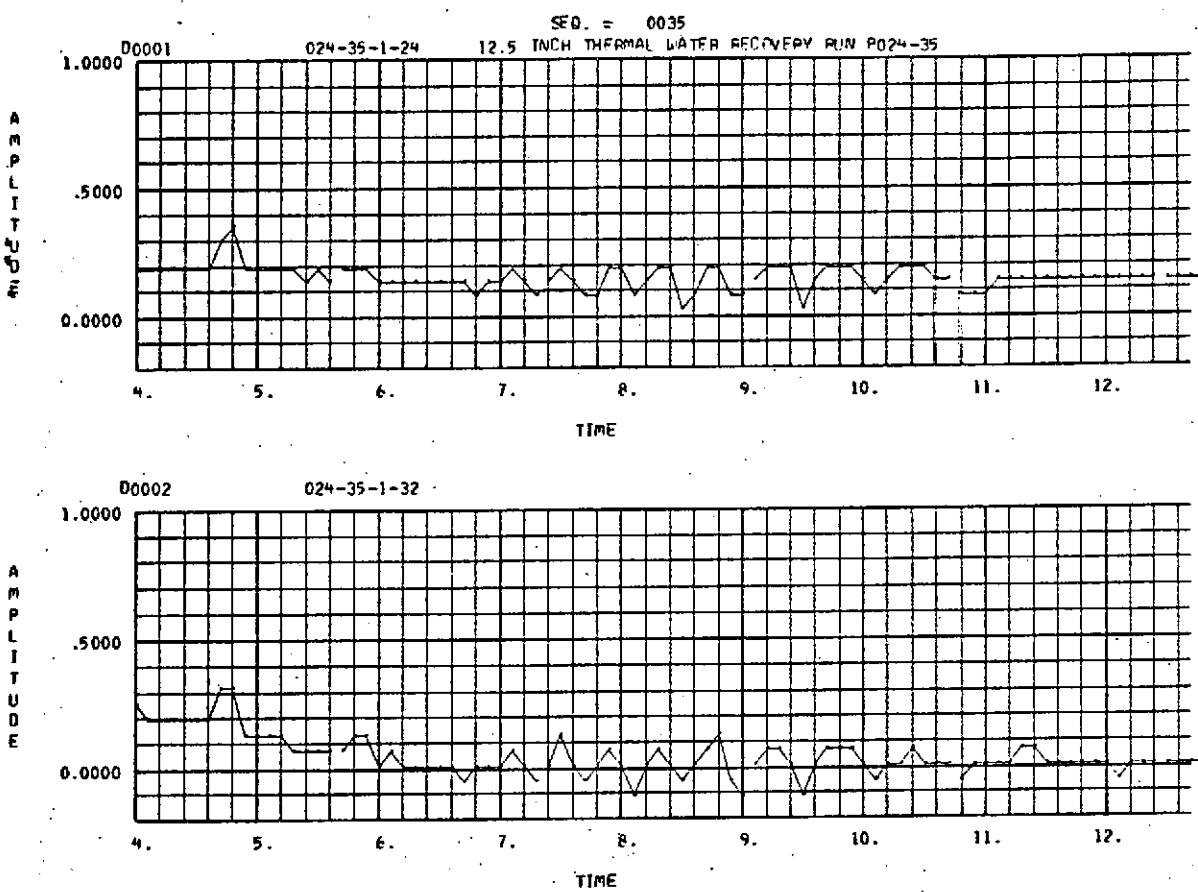
C0008 024-35-1-96



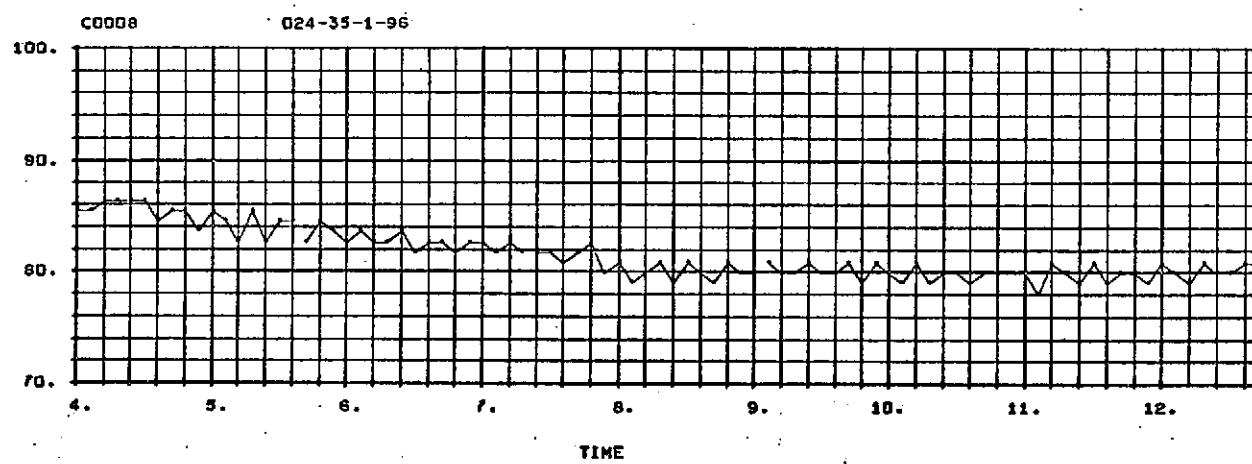
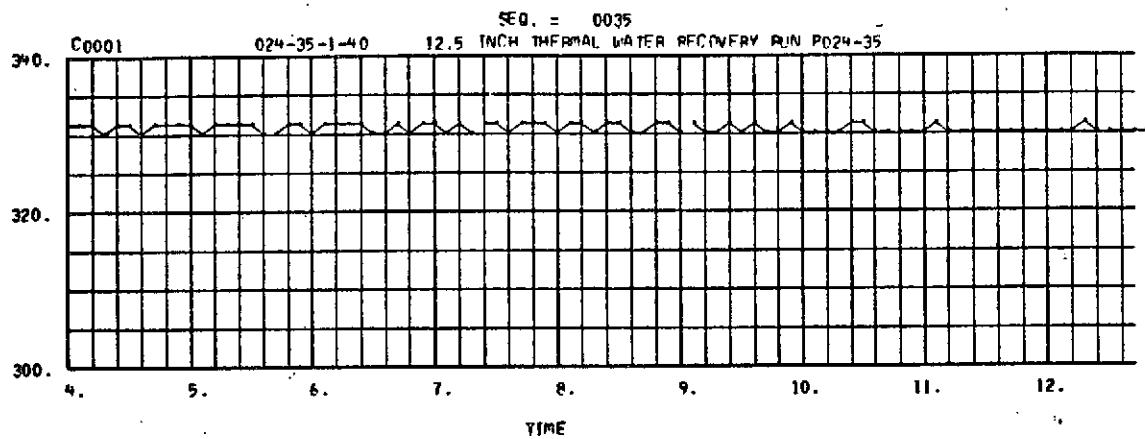
B-273

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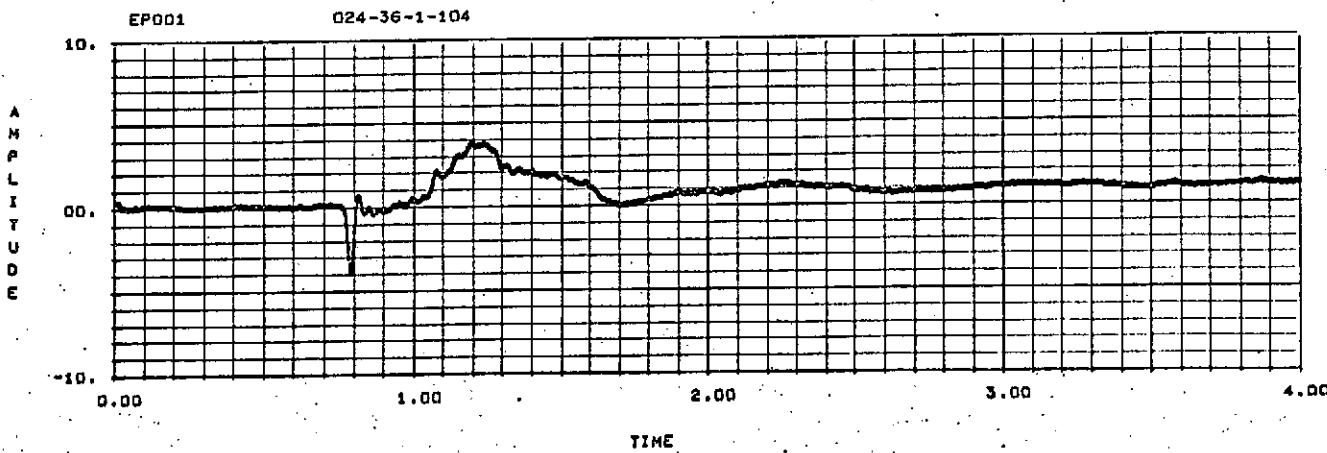
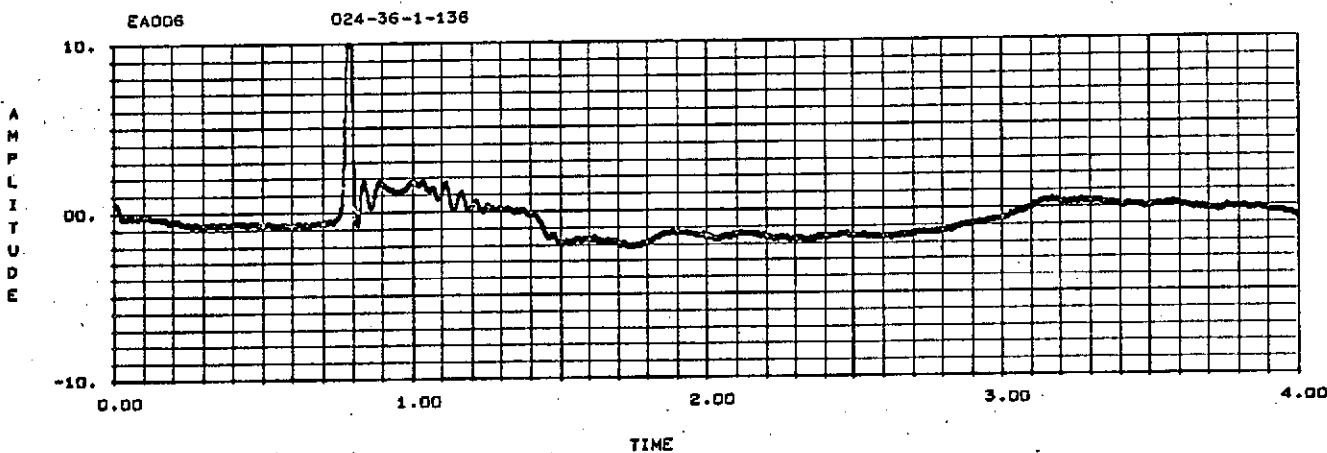
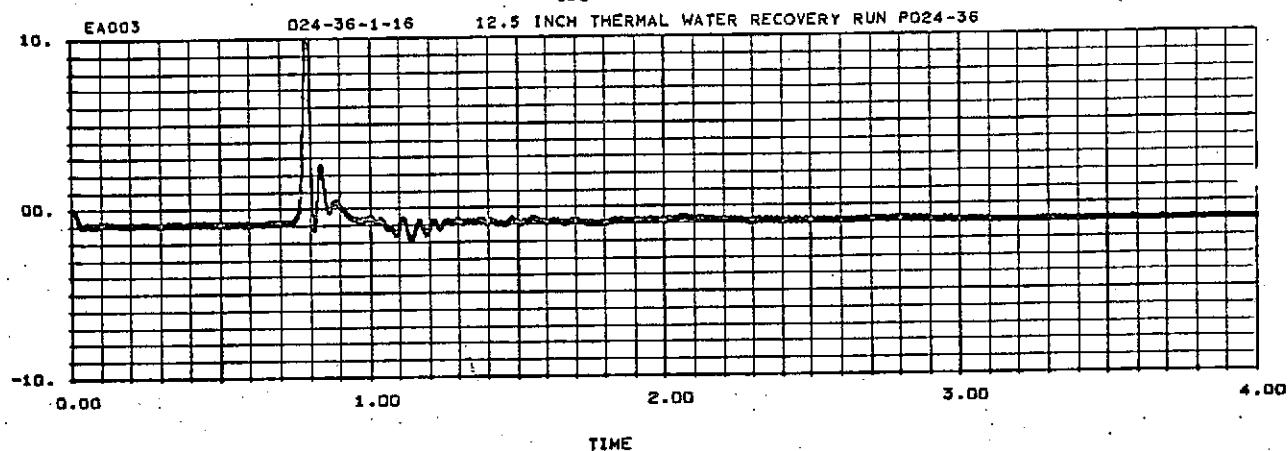




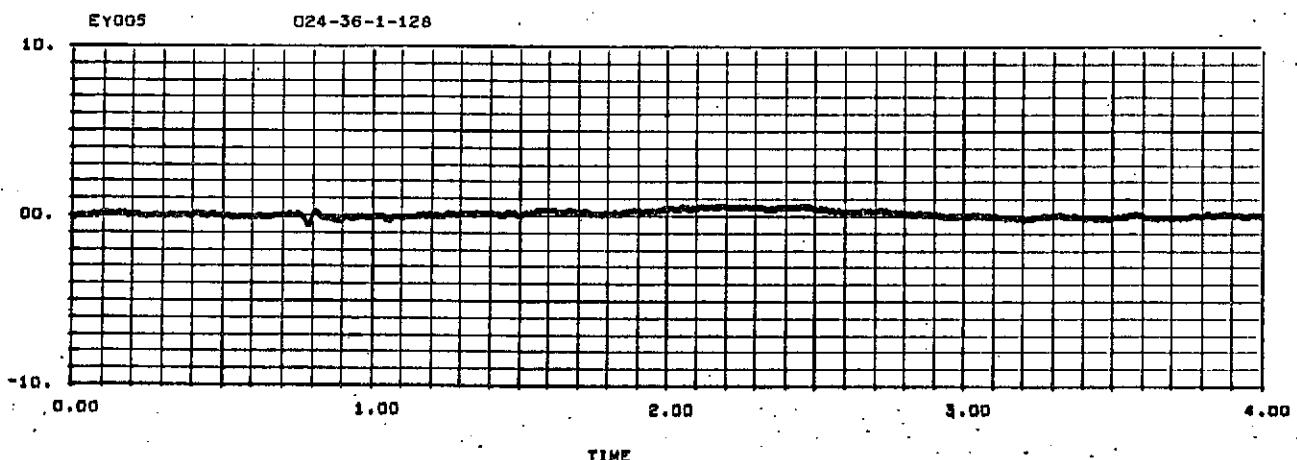
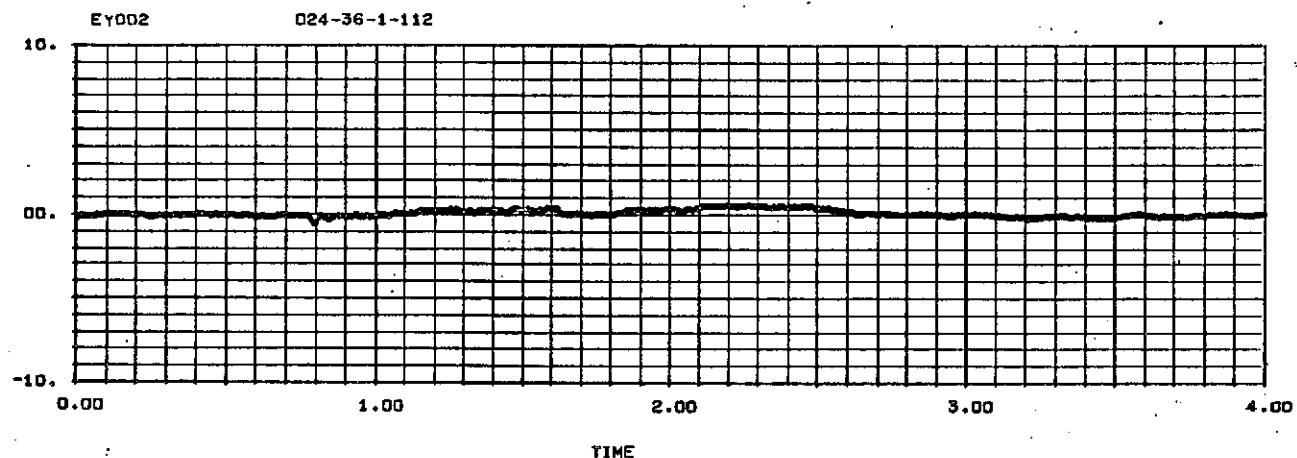
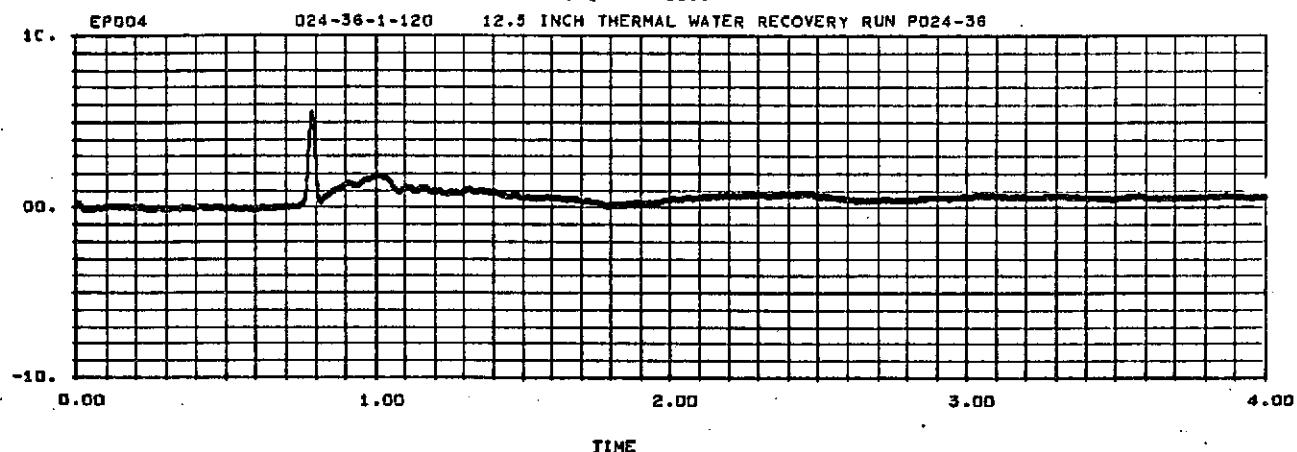
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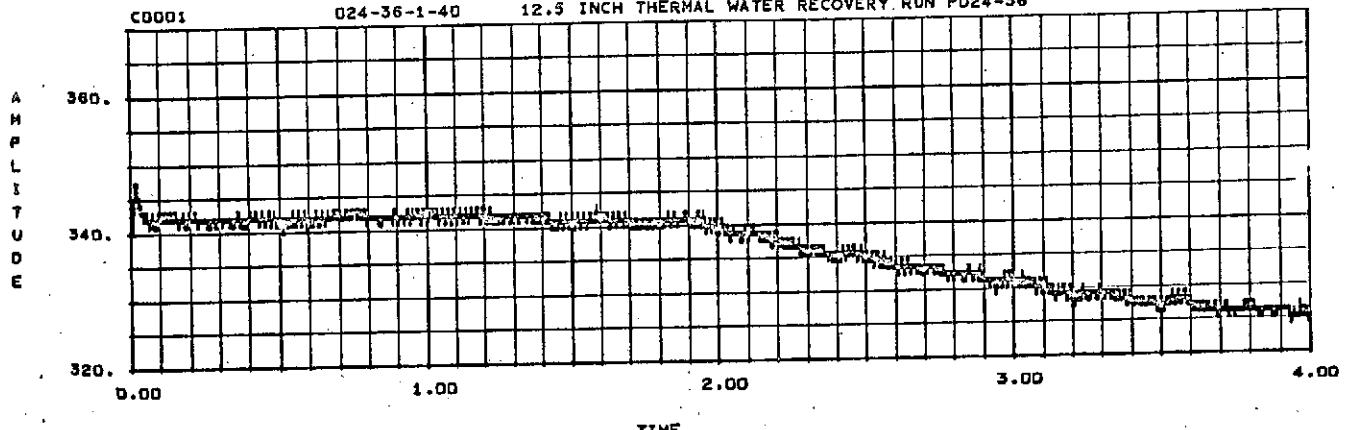


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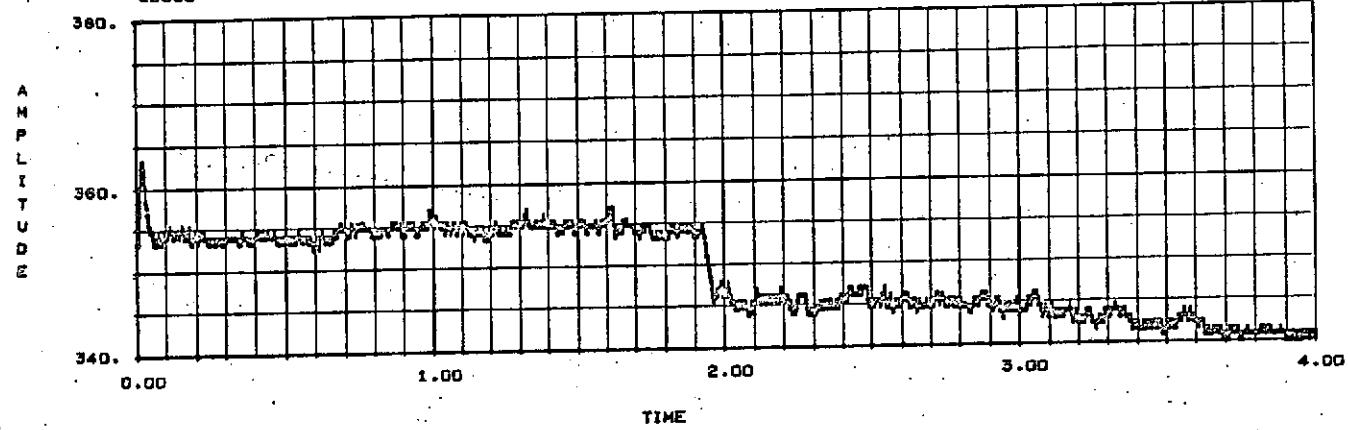


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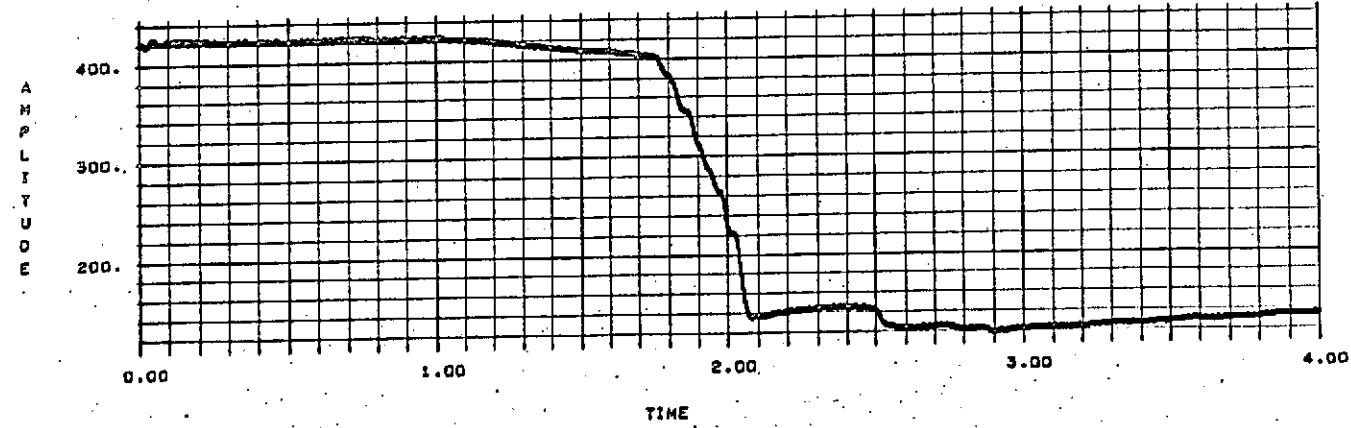
024-36-1-40 12.5 INCH THERMAL WATER RECOVERY RUN P024-36



C0002 024-36-1-48

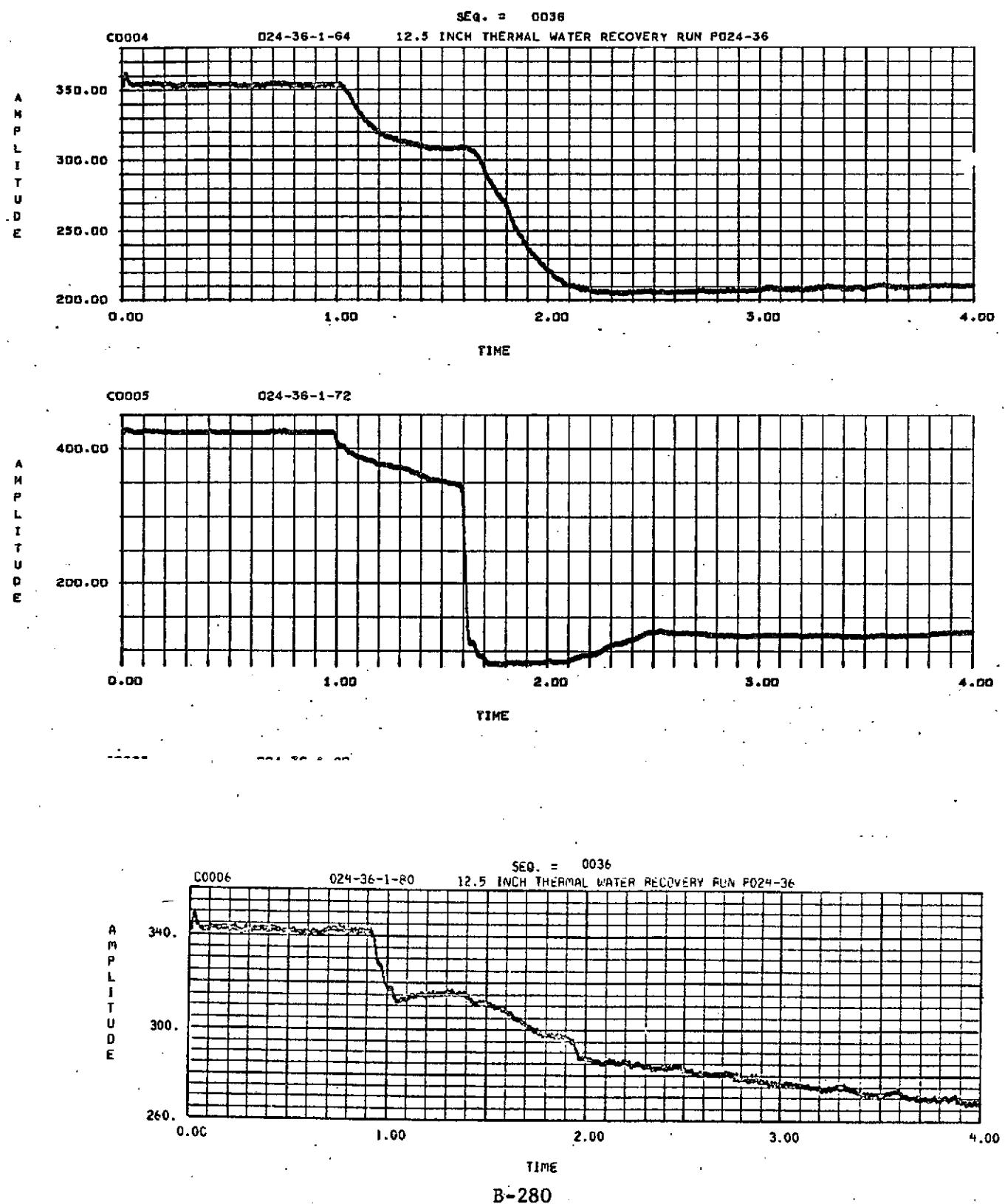


C0003 024-36-1-56



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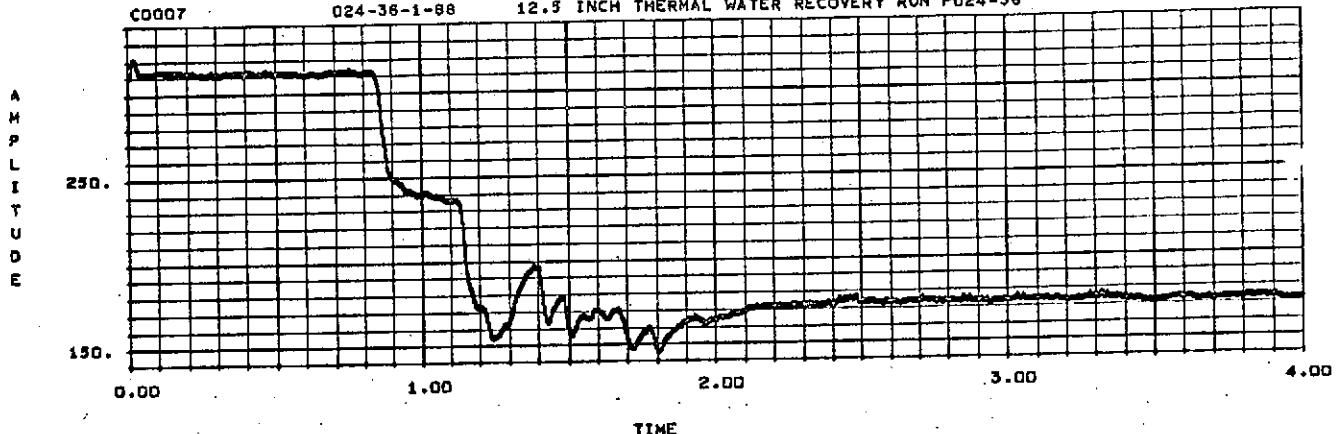


B-280

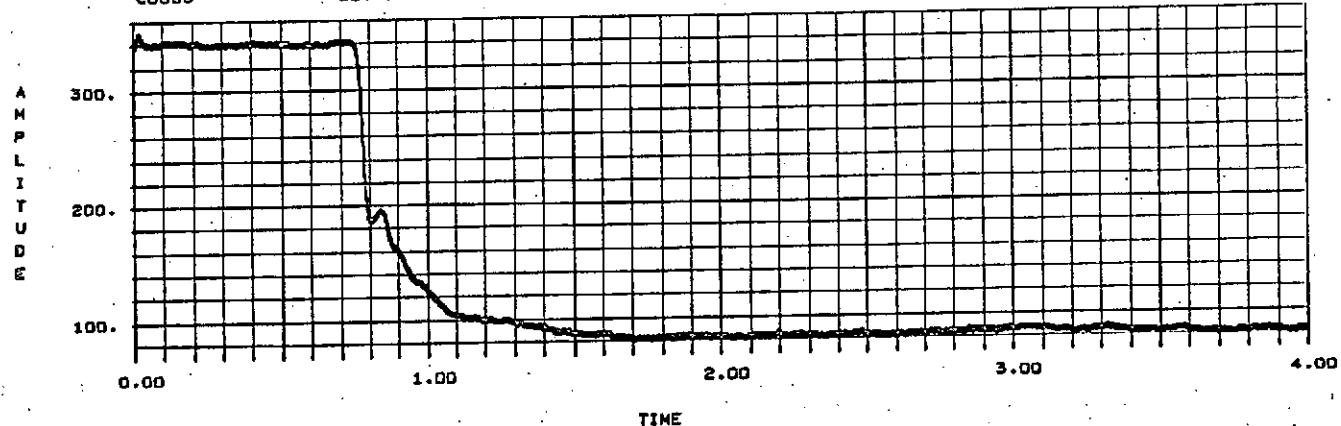
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024-36-1-96

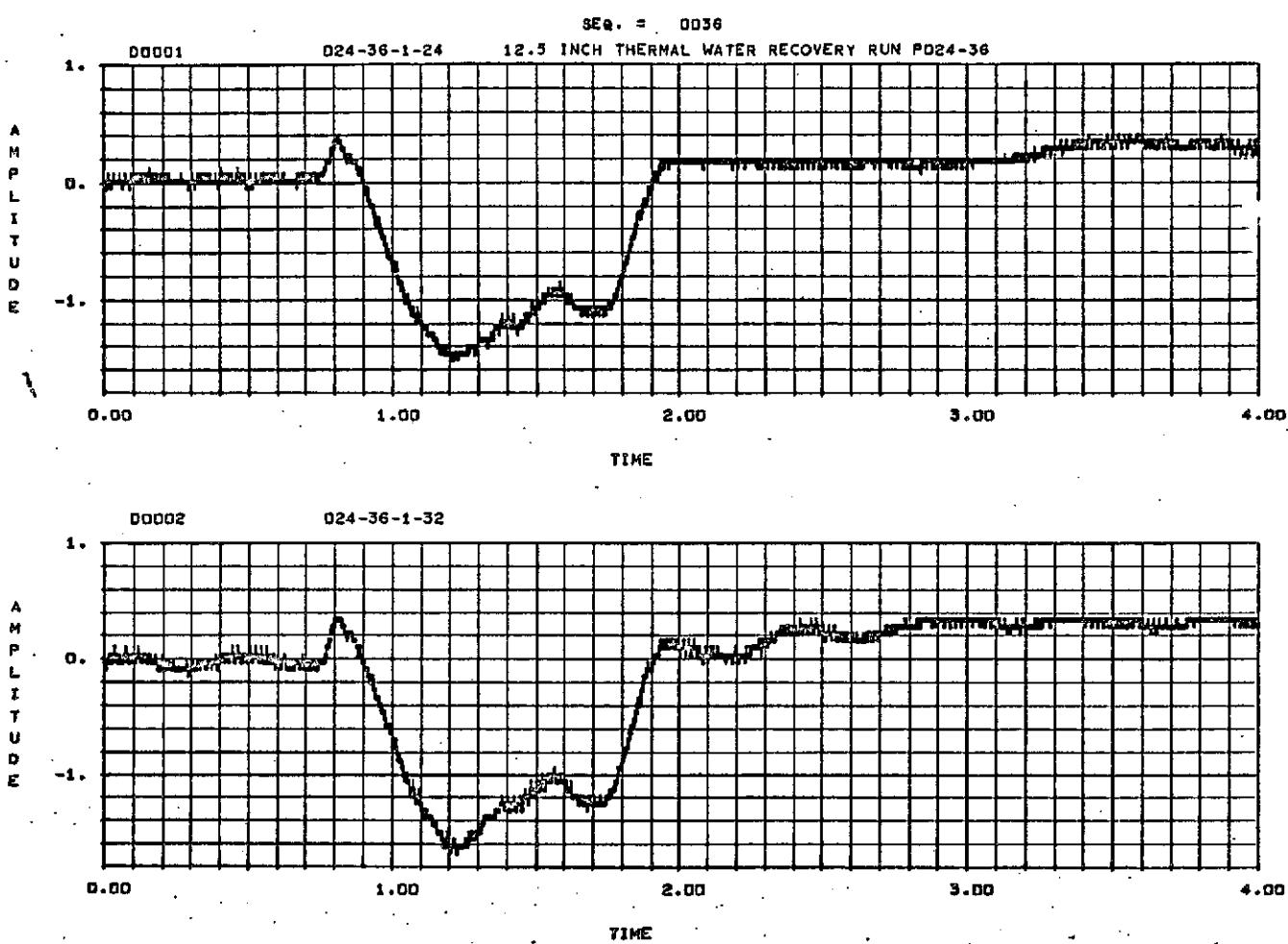
12.5 INCH THERMAL WATER RECOVERY RUN P024-36

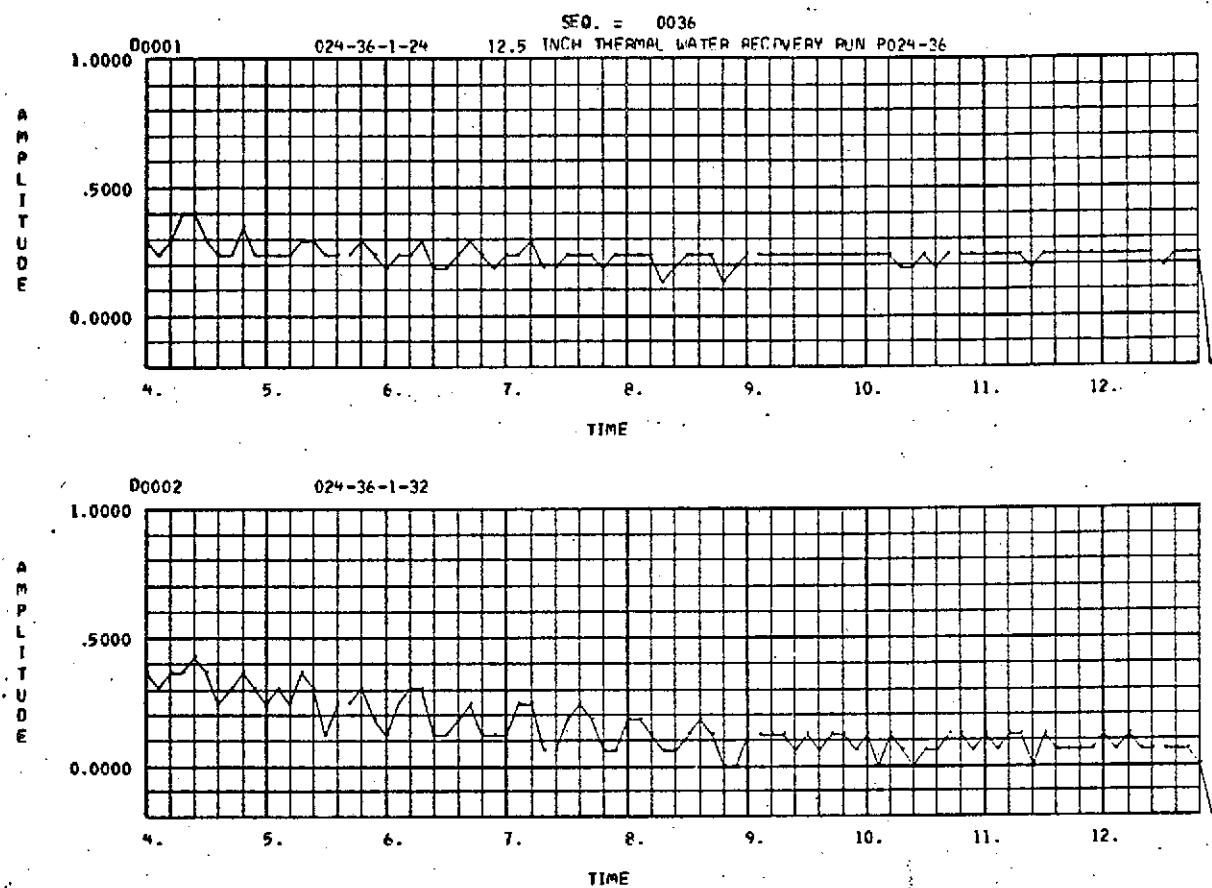


C0008 024-36-1-96



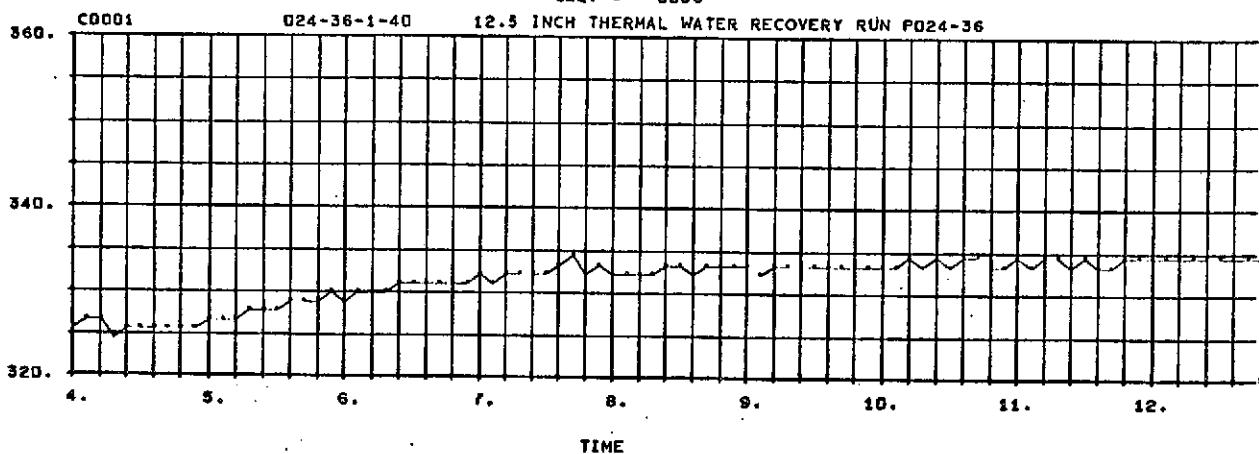
REPRODUCIBILITY OF THE
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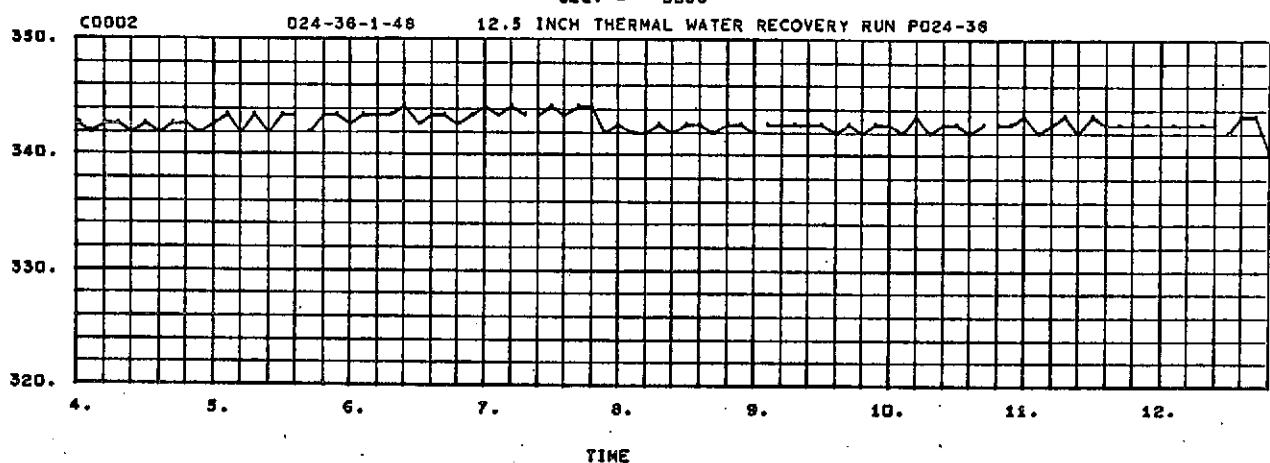


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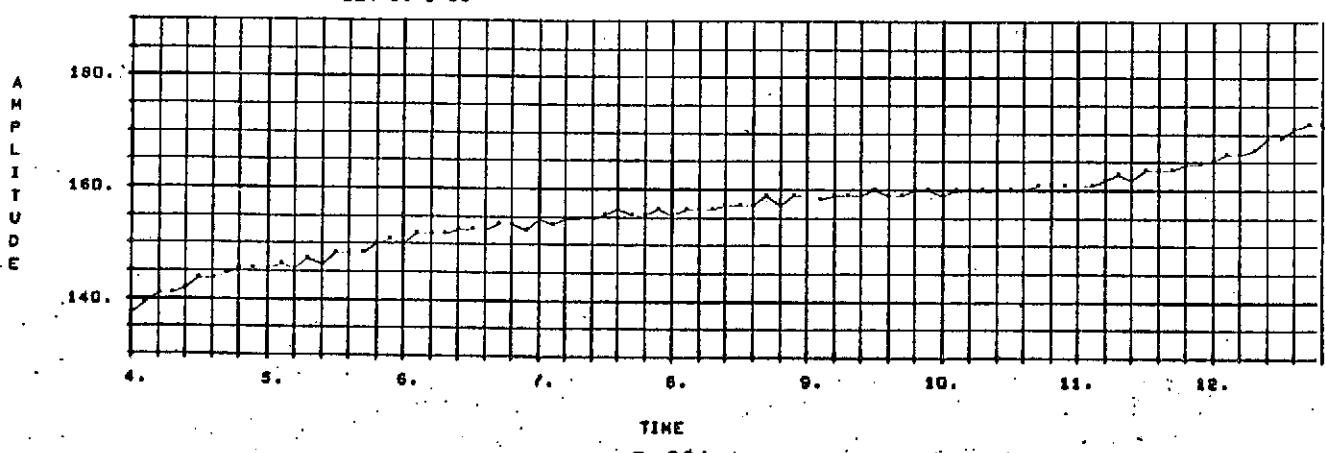
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SEQ. = 0036



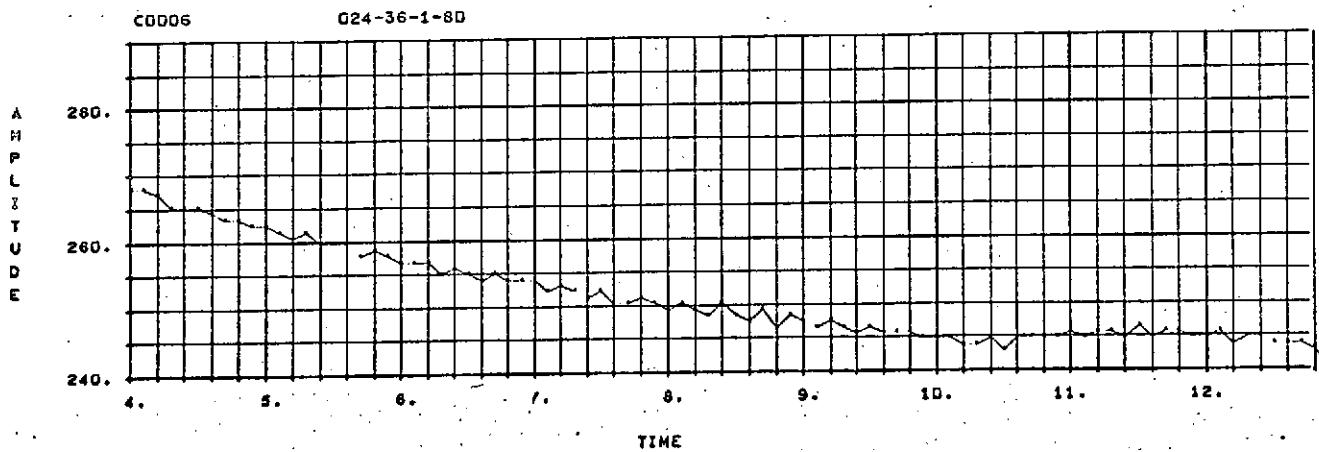
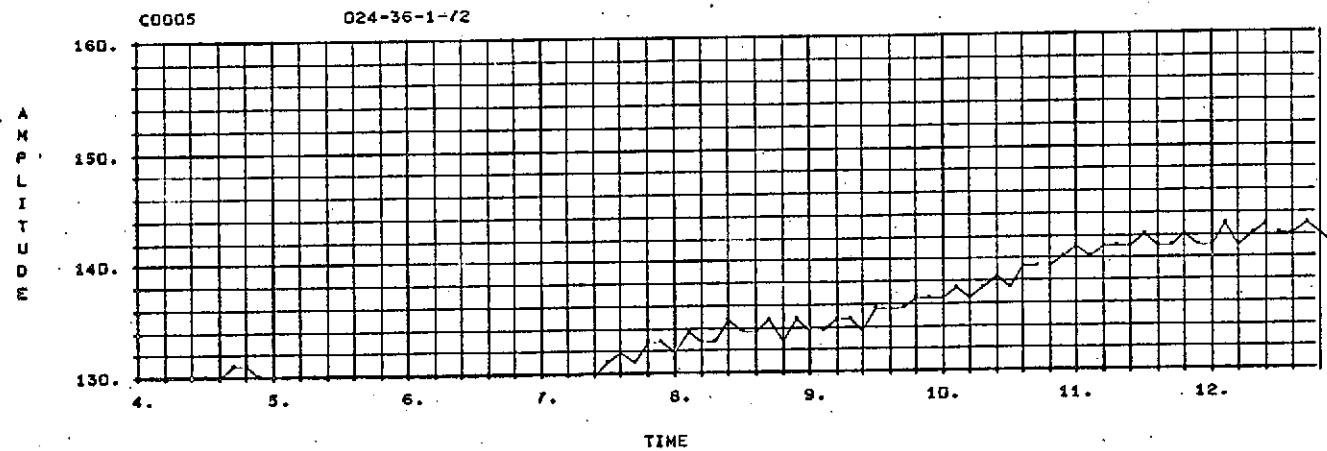
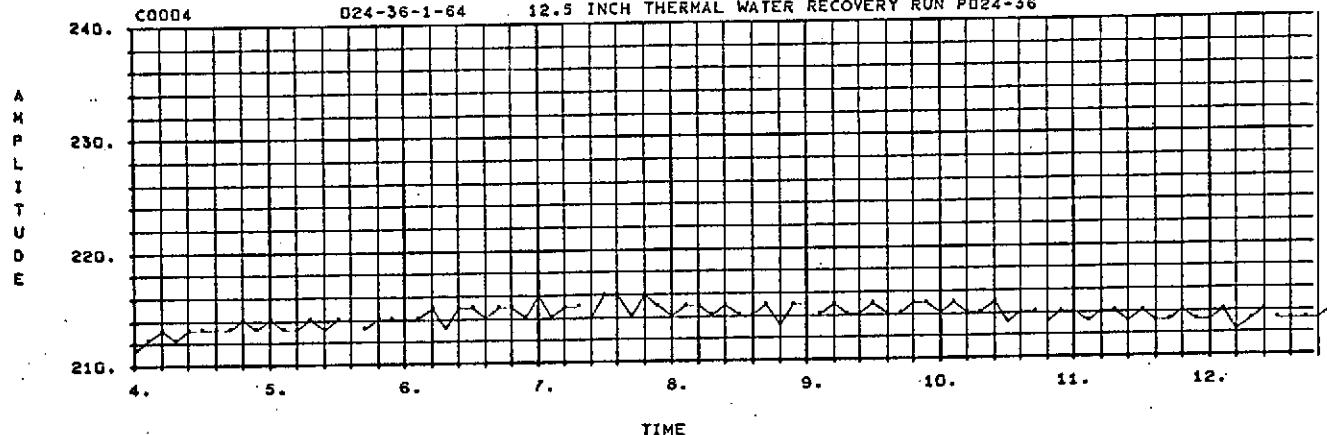
C0003 024-36-1-56



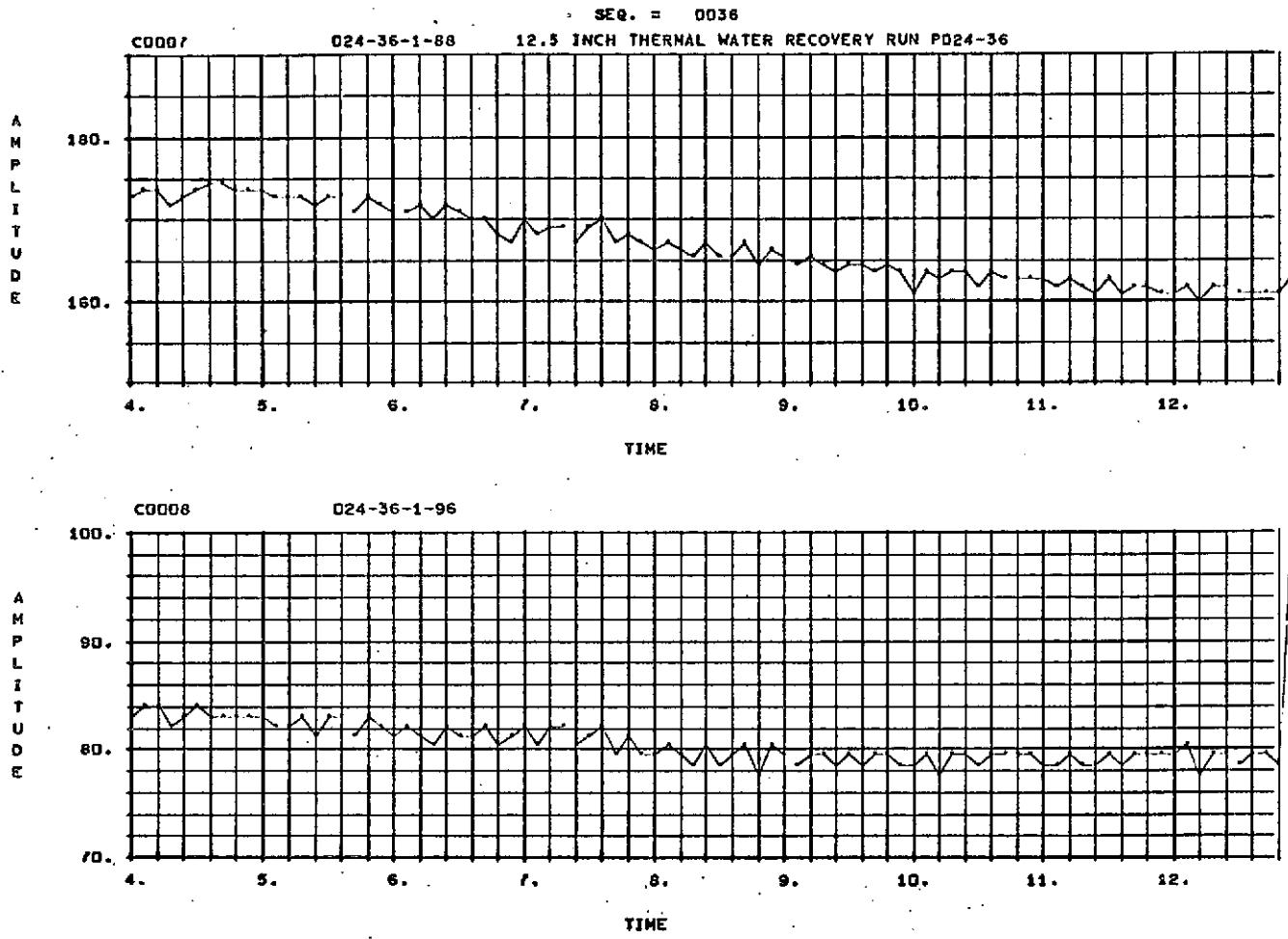
B-284

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024-36-1-64 12.5 INCH THERMAL WATER RECOVERY RUN P024-36



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